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PRIMARY SARCOMA OF THE IRIS (MALIGNANT MELANOMA)

A REPORT OF THREE CASES

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Primary sarcoma of the iris is a relatively rare condition which occurs most frequently between the thirty-fifth and the fifty-fifth year. It is more common in females than in males. Pigmented spots in the iris, which are congenital, are not uncommon. They are seen as nevi, which usually lie in the anterior limiting layer and are often near the papillary border. These vary in size from a pinpoint to a large segment of the iris. Sometimes they are highly vascularized (nevus vasculosus). A nevus may give rise to a definite tumor, which is usually benign but may become malignant. Among 26 cases of innocent nevi under observation by Coats,[1] the condition in 7 became malignant.

Serous cysts also occur in the iris. They are filled with a clear substance and develop within the stroma of the iris, so that their walls are formed by rarefied iris tissue. One also finds benign melanoma in the iris, especially at the pupillary border. It may occur in the neighborhood of the peripheral edge of the sphincter or at the extreme periphery of the iris. Tuberculosis of the iris may occur as a solitary tubercle resembling a neoplasm. Thus the differential diagnosis of a tumor of the iris may present some difficulty. A nonpigmented nodular tumor may be a syphilitic growth, a solitary tubercle, nonpigmented sarcoma or granuloma about an embedded foreign body.

The incidence of malignant melanoma in the choroid, ciliary body and iris is about as 85 to 9 to 5, that is somewhat proportional to the amount of uveal pigment present. Fuchs [2] found sarcoma of the iris 16 times in 259 cases of uveal sarcoma, Martin once in 43 cases and Lawford and Collins [3] once in 102 cases. The 3 cases here reported occurred among 43 cases of sarcoma of the uveal tract.

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1. Coats, G.: Tr. Ophth. Soc. U. Kingdom **32**:165, 1912.
2. Fuchs, E.: Das Sarkom des Uvealtractus, Vienna, W. Braumüller, 1882.
3. Lawford, J. B., and Collins, E. T.: Roy. London Ophth. Hosp. Rep. **13**:2, 1891.

The method of origin of the melanosarcoma is still the subject of considerable controversy. There are still various opinions that the growth arises from endothelium, from epithelium and from the chromatophores. Mary Knight,[4] who reported 7 cases, stated the belief that this type of tumor is epithelial in origin, reasoning that only ectodermal cells produce melanin. The intracellular production of melanin is then a point in favor of the epitheliomatous rather than of the sarcomatous nature of the tumor. In the choroid there are two types of cells which contain a golden brown granular pigment: (1) epithelial spindle-shaped or oval-shaped cells which contain and produce in their protoplasm the metabolic substance known as melanin and (2) so-called chromatophore cells, which are branched phagocytic reticular epithelial cells containing some pigment but having a foreign body product thrown off by the pigmented epithelium. The benign melanoma, or pigmented mole, of the choroid is made up of both these types, but it is the former which undergoes malignant transformation and gives rise to a tumor. The cells of the latter type are pushed aside by the growth and form its deeply pigmented margin.

Verhoeff [4] suggested that one would naturally suppose that sarcoma actually arises from melanoma, but how is one to prove it? It is generally conceded that the tumor known as sarcoma of the uvea arises from the chromatophores, and it is therefore impossible to escape the conclusion that the tumor is mesoblastic in origin. Masson [5] suggested a neuroectodermal origin of nevi and of melanosarcoma of the skin. He demonstrated an association of these growths with terminal end organs of the sensory nerves. The ectodermal origin of uveal sarcoma seems to be gaining in favor. In 1937 Theobald [6] wrote as follows:

> The main object of this paper is to show that those neoplasms of the choroid which have hitherto been described in the literature as choroidal sarcomas are more probably neurogenic tumors arising from the Schwann sheath cells of nerves traversing the choroid. The neural origin of the so-called sarcoma of the choroid will be supported by the histologic findings in seven cases which I have studied.

The classification of this tumor as sarcoma has been questioned, and the term "malignant melanoma" has been suggested as a more proper one. Callender [7] in 1931 and Callender and Wilder [8] in 1935 reported on a classification of the tumor as spindle cell with subtypes A and B, fascicular, epithelioid and mixed. A necrotic type has since

4. In discussion on Wagener, H. P., and Wellbrock, W. L. A.: Tr. Am. Ophth. Soc. **28**:101, 1930.
5. Masson, P.: Am. J. Path. **8**:367 and 389, 1932.
6. Theobald, G. D.: Tr. Am. Ophth. Soc. **35**:303, 1937.
7. Callender, G. R.: Tr. Am. Acad. Ophth. **36**:131, 1931.
8. Callender, G. R., and Wilder, H. C.: Am. J. Cancer **25**:251, 1935

been added. Necrosis of the tumor often recurs and may confuse the clinical picture considerably.

Tay [9] in 1866 reported a case of primary cancer of the iris. This is probably the first case in which a histologic examination was made. Tay described it as follows:

A. W., a man aged 25, was seen because of a growing tumor in connection with the lower part of the left iris. The eye was not inflamed; the tumor grew slowly until it almost filled the anterior chamber and prevented vision by covering the pupil. The cornea remained clear, so that the progress of the tumor could be clearly seen. It was a grayish, jelly-like mass, with opaque points scattered through it, and was abundantly supplied with minute blood vessels. Until the pupil was covered, the sight remained perfect. The date of onset could not be determined, but ten years previously the eye had been the subject of considerable interest to several of the hospital surgeons. At length the pupil became covered and the eye useless, and removal was advised. The curator reported that the growth consisted of a soft, grayish brown mass, which adhered to the cornea and had apparently grown from the iris and the ciliary processes. About half of the iris was involved. The tumor was considered "medullary cancer with pigment" by the curator.

Cowell [10] reported a case of cancer of the eyeball commencing in the ciliary region and presenting itself through the iris. This occurred in a joiner by trade, aged 24 years.

Stöber [11] in 1853 had described a case observed in the years 1830 to 1835. There was here, however, no histologic report.

Recorded cases were collected by Knapp [12] in 1879, Fuchs [2] in 1882, Collins [13] in 1889 and Wood and Pusey [14] in 1902. The last-named authors gave abstracts of 83 cases in each of which a microscopic examination was made. In 35 of the cases the primary seat was in the lower part of the iris, in 13 it was in the upper half, in 5 it was in the inner side and in 2 it was in the outer side. Sarcoma of the iris is usually melanotic. The tumor is at first small and in many cases has grown for months or even years without causing vascular injection of the eye or interfering with the mobility of the iris. It is frequently nodular and always very vascular, the vessels being visible to the naked eye. Sometimes several tumor masses occur in the same iris. Pigmented and nonpigmented nodules may appear side by side. Iritis may not be present until the tumor has been present for a considerable time; in fact, the inflammatory reaction is generally slight until secondary glaucoma intervenes. In some cases the first symptom of the condition has been caused by recurrent hemorrhages in the anterior chamber

9. Tay, W.: Ophth. Hosp. Rep. **5**:230, 1866.
10. Cowell, G.: Ophth. Hosp. Rep. **5**:189, 1866.
11. Stöber, V.: Ann. d'ocul. **30**:265, 1853.
12. Knapp, H.: Arch. Ophth. **8**:82, 1879.
13. Collins, E. T.: Roy. London Ophth. Hosp. Rep. **12**:255, 1888-1889.
14. Wood, C. A., and Pusey, B.: Arch. Ophth. **31**:323, 1902.

which have drawn attention to the presence of the growth in the iris. In other cases involvement of the pupillary area of the iris has led to disturbance of vision. The tumor usually grows more quickly in the later stages; sometimes it actually fills the anterior chamber, and it has been known to perforate the wall of the globe, the process leading to extraocular growth. Early and extensive involvement of the ciliary body often renders it impossible to decide where the primary seat of the tumor was.

In 1868 Hirschberg [15] and Lebrun [16] reported cases of primary sarcoma of the iris in which a microscopic examination was made. In 1876 Kipp [17] reported a case and furnished a review of the literature up to that date. In 1879 Knapp [12] reported 3 cases of successful removal of sarcoma of the iris. In 1882 "Das Sarkom des Uvealtractus" by Fuchs [2] appeared. In 1902 Wood and Pusey [14] gave abstracts of 83 cases in which a microscopic examination had been made. Through the years a number of reports have appeared in the literature. Fairly recently Mayou [18] reported a series of 4 cases of sarcoma of the iris, and Duke-Elder and Stallard [19] reported 1 of leukosarcoma of the iris. In 1938 Siegert [20] gave the clinical and pathologic observations on 3 cases of sarcoma of the iris without involvement of the rest of the uvea. In the first case a small sarcoma which had arisen from a nevus was discovered accidentally in the course of routine pathologic examination. The observations made on these 3 cases confirmed the classic concept of the origin of sarcoma from benign melanoma, in the opinion of Siegert.

Case 1.—Mrs. R. G., a French-Canadian of 53, was first seen in March 1937 when she came to the outpatient clinic complaining of a tarsal cyst of the lid for which she desired treatment. During the examination of her eye a small tumor of the iris of the right eye was noticed. On the nasal portion of the right iris at about 3 o'clock there was seen a vascularized pinkish growth approximately 3 mm. long by 2 mm. wide. The tumor extended into the anterior chamber, appearing to touch the posterior surface of the cornea; the angle of the chamber seemed filled with tumor which touched the peripheral edge of the pupil on the other side. The eye was free from inflammation.

The striking feature of the growth in the iris was its vascularity. The vision was normal. The patient was advised as to the suspicion about the tumor and was recommended to keep in touch with the clinic for observation. She was seen at intervals, and when later on it could be definitely seen that the tumor growth had increased in size she was advised to have the eye enucleated. This she did

15. Hirschberg, J.: Arch. Ophth. **14**:285, 1868.

16. Lebrun: Ann. d'ocul. **60**:208, 1868.

17. Kipp, C. J.: Arch. Ophth. **5**:34, 1876.

18. Mayou, M. S.: Brit. J. Ophth. **14**:152, 1930.

19. Duke-Elder, W. S., and Stallard, H. B.: Brit. J. Ophth. **14**:158, 1930.

20. Siegert, P.: Arch. f. Ophth. **139**:591, 1938; abstracted, Arch. Ophth. **23**: 218 (Jan.) 1940.

not wish to have done, but finally in November, some eight months after she first came under observation, she came into the hospital and had the eye removed.

Examination of the specimen showed an alveolar arrangement of the cells, which were in compact alveoli with a delicate vascular stroma between. The growth was vascular, and the alveoli were seen to anastomose one with the other. The cells were of the large polygonal type and were definitely not spindle. They were distorted from being squeezed together. The large polygonal cells had large nuclei with clearcut nuclear membranes. There was a granular distribution of chromatin with distinct and large eosinophilic nuclei. There were no mitotic figures. The tumor was typed according to the Callender classification as "mixed," with a definite amount of fascicular arrangement of the cells. The amount of pigment

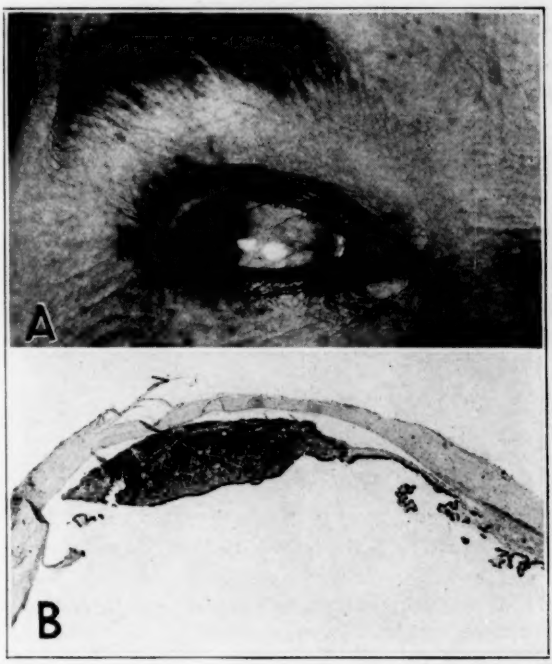

Fig. 1 (case 1).—*A*, the involved eye; *B*, section through the iris and the tumor.

was scanty; it was seen in the stroma and in some of the tumor cells. The Laidlaw stain showed a rich network of argyrophil fibers in the supporting stroma about the tumor alveoli. The fibers were numerous at the periphery of the tumor mass and absent or scanty in the center of the tumor. The tumor was later sent to the American Registry of Pathology and typed "mixed cell type, less than 50 per cent argyrophil fibered (2A)."

CASE 2.—Mr. H. S., aged 69, was first seen when admitted to the hospital in April 1939. He had been admitted for relief of nasal polyps, and during routine examination a tumor of the iris was found. The patient stated that the tumor had been present, he thought, for about forty years and in that time had not changed any in appearance to his knowledge. Apart from wearing glasses for reading, he had had no trouble whatever with his eyes.

In the right eye there was seen a fairly large, reddish tumor of the iris occupying an area from 3 to 5 o'clock. The tumor involved the iris from the pupillary border to the angle and seemed to be pushed into the latter, the surface being pressed smoothly against the posterior surface of the cornea so that it assumed the shape of that surface in its temporal position. The tumor was lobulated, especially in the nasal part, and was very vascular. There was noted one large vessel on the surface of the tumor. A small amount of pigment was seen on the surface of the tumor near the lid. There was considerable ectropion of iris pigment in the immediate region of the tumor. The patient was advised to have the eye removed.

Pathologic examination of the eyeball showed that the tumor involved half the width of the iris, extending from the ciliary body on one side, and was roughly fusiform. The iris could be traced through the tumor, which bulged forward somewhat. The pigment layer had been displaced and here and there was incorporated in the tumor in a definite fascicular arrangement. The tumor was made up of small oat-shaped cells which had relatively large nuclei and were closely

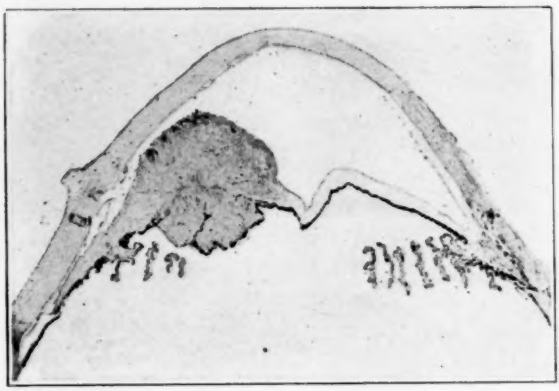

Fig. 2 (case 2).—Section through the iris and tumor.

packed together. It was traversed by only a few vessels, and these were found in the connective tissue strand. There were not a lot of thin-walled vessels, as in case 1. Only a few of the cells had nucleoli. They were regular on the whole, and a number contained vacuoles. There was no pigment seen in the cells except here and there along the margin of the pigmented zone. The tumor was definitely not epithelioid, and it was classified fascicular. The stain for argyrophilic fibers showed that there were few fibers present except in the stroma. There were practically none between the cells.

CASE 3.—Miss G. C., aged 41, was admitted to the hospital in September 1940 with the complaint of a growth in the left eye. She gave a history of having noticed a small brown area on the iris of her left eye for the first time in May 1939. She consulted a local oculist, who had her under observation until the time of her admission to the hospital. She stated that during the last month the growth had changed considerably and had noticeably increased in size. It was for this reason that she came to consultation.

Examination showed a small brown tumor, slightly oval in outline, situated on the nasal side of the iris from about 8 to 10 o'clock. There was some flattening

of the iris there, with irregularity of the pupil, from posterior synechias. The tumor was strikingly vascular. The eye was enucleated, and the pathologic examination disclosed the following picture:

The tumor occupied the full thickness of the iris and extended into the ciliary body. It was composed of large polygonal and stellate cells, which appeared to fuse one with another, forming a meshwork enclosing clear spaces. The cytoplasm was exceedingly fascicular; the cells, with large fascicular nuclei, contained variable amounts of granular chromatin scattered throughout the nuclei. The nuclear membrane was distinct. There were large eosinophilic nucleoli in the majority of the cells. There was a considerable amount of pigment scattered throughout. This was found chiefly in the cells, there being little in the intervening stroma. The

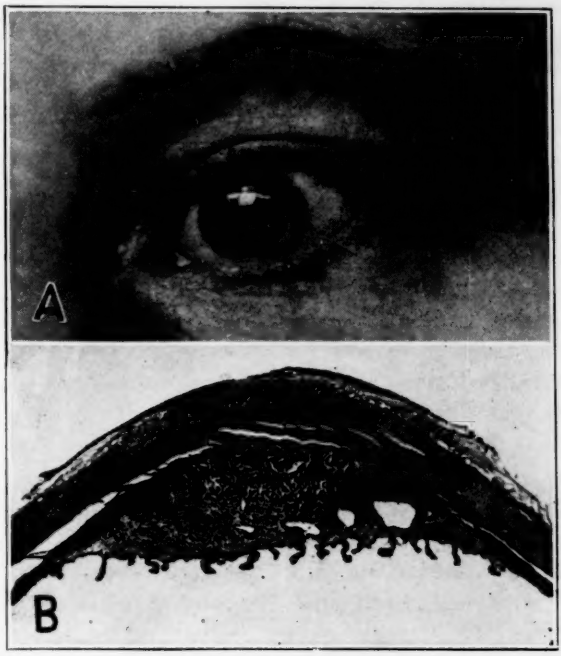

Fig. 3 (case 3).—*A*, the involved eye; *B*, section through the iris and tumor.

tumor was vascular in the deeper parts, and in the center there was a peculiar arrangement of convoluted cords of more or less columnar cells, arranged in palisaded fashion, with the long axis of the cells at right angles to the long axis of the cords. Between these convolutions there were seen clear spaces which were traversed by thin eosinophilic fibers, which appeared to be cell processes. The tumor was classified "spindle-B."

COMMENT

Of the 3 cases here reported, noted among a series of 43 cases of malignant melanoma, the patient in only 1 came to consultation because of the tumor of the iris. In the other 2 the tumor was observed during routine examination of the eye. There were 2 women and 1 man; their ages, respectively, were 53, 41 and 69.

Primary tumors of the iris have a low mortality, probably because they are recognized easily and dealt with properly early.

A striking clinical feature of the 3 cases here reported was the vascularity of the tumors.

Sarcoma of the iris seems to react temporarily, but not permanently, to irradiation (roentgen rays), though Stallard [21] in 1932, after an exhaustive study, found no authentic case of melanosarcoma of the eye benefited by roentgen ray or radium treatment.

Tumors of the iris grow slowly and metastasize through the lymphatic channels. It is often difficult to determine with certainty from which normal tissue elements of the iris such a tumor is derived.

In many cases melanosarcoma of the skin has developed from a nevus which has remained unchanged for years; so it is not unreasonable to suppose that a similar growth in the iris may not have developed from a nevus there. Mayou [18] in 1930 reported melanosarcoma of the iris observed for thirteen years before removal; other ophthalmologists have watched tumors of the iris over a period of years before removal of the eye.

If the tumor is localized in the iris and a complete removal by iridectomy can be performed, it is permissible; however, when the removal is incomplete the trauma serves as a stimulus for a more rapid growth of the tumor.

The question of syphilis or of tuberculosis may be decided by a diagnostic injection of tuberculin or by the Wassermann test.

"If you use a mydriatic and find the pupil is not round, and the iris does not react normally at the site of the tumor, I think it is important evidence that you are dealing with a malignant tumor" (Verhoeff [4]).

According to observations of Wilder and Callender, the epithelioid type is the most malignant, and the spindle cell type A, relatively benign. In the classification by fiber content, malignancy of the tumor appears to be inversely proportional to the degree of intercellular invasion by argyrophil fibers. "Clinically, the development of a malignant tumor in the iris from a melanoma is characterized by the increased growth of the process on the surface of the iris, by a probable change in the color of the newly formed tumor from that of the original melanoma, and by the encroachment and invasion of the chamber angle with the early development of glaucoma" (A. Knapp [22]).

Microscopically, the tumor growth is diffuse and in this respect differs from benign melanoma. Karyokinetic figures are almost invariably absent—a striking difference from sarcoma.

1528 Crescent Street.

21. Stallard, H. B.: Brit. J. Ophth., 1933, supp. 6, p. 1.
22. Knapp, A.: Tr. Am. Ophth. Soc. **28**:118, 1930.

SODIUM SULFATHIAZOLE IONTOPHORESIS

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Experimentally, the bacteriostatic effectiveness of sulfathiazole (2-[paraaminobenzenesulfonamido]-thiazole) in vitro is equal to,[1] and in many instances greater than,[2] that of sulfanilamide and other derivatives against infections produced by such organisms as Staphylococcus aureus,[3] Bacillus proteus,[1a] Streptococcus (hemolytic),[4] Pneumococcus [5] (types I, II and III) [5] and Gonococcus.[2a]

It is reasonable to expect satisfactory clinical results in ophthalmology if an adequate concentration of the drug can be introduced into the ocular fluids and tissues. The experiments of Bellows and Chinn and others [6] have shown that oral therapy is inadequate. As far as is known, the local application of sulfathiazole has not been investigated experimentally.[7]

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This study was made possible by a grant from the Knapp Memorial Foundation Fund.

1. (*a*) Long, P. H., and Bliss, E. A.: Bacteriostatic Effects of Sulfathiazole upon Various Micro-Organisms: Its Therapeutic Effects in Experimental Pneumococcal Infections, Proc. Soc. Exper. Biol. & Med. **43**:324, 1940. (*b*) King, J. T., and Henschel, A. F.: Bacteriostatic Effect of Sulfathiazole and Sulfamethylthiazole for Beta Hemolytic Streptococci in Tissue Culture Clots, ibid. **44**:268, 1940.

2. (*a*) Lawrence, C. A.: Bacteriostatic Actions of Three Thiazole Derivatives of Sulfanilamide upon Bacteria in Broth Cultures, Proc. Soc. Exper. Biol. & Med. **43**:92, 1940. (*b*) Rammelkamp, C. H., and Keefer, C. S.: Sulfathiazole: Effect on Staphylococcus Aureus in Vitro, ibid. **43**:664, 1940. (*c*) Rake, G., and McKee, C. M.: Action of Sulfathiazole and Sulfamethylthiazole on Staphylococcus Aureus, ibid. **43**:561, 1940.

3. Long and Bliss.[1a] Rammelkamp and Keefer.[2b] Rake and McKee.[2c]

4. Long and Bliss.[1a] King and Henschel.[1b] Lawrence.[2a]

5. Long and Bliss.[1a] Lawrence.[2a]

6. (*a*) Bellows, J. G., and Chinn, H.: Penetration of Sulfathiazole in the Eye, Arch. Ophth. **25**:294 (Feb.) 1941. (*b*) Scheie, H. G., and Souders, B. F.: Penetration of Sulphanilamide and Its Derivatives into Aqueous Humor of Eye, ibid. **25**:1025 (June) 1941. (*c*) Liebman, S. D., and Newman, E. H.: Distribution of Sulphanilamide and Its Derivatives Between Blood and Aqueous, ibid. **26**:472 (Sept.) 1941.

7. Since the submission of this paper for publication sulfathiazole has been shown to penetrate the eye poorly after local application (Chinn, H., and Bellows, J. G.: Corneal Penetration of Sulfanilamide and Some of Its Derivatives, Arch. Ophth. **27**:34 [Jan.] 1942).

The local application of other compounds of the group has met with limited experimental success. Except in the case of sulfanilamide, the concentrations obtained in the eye were too low to be of clinical value. Mengel [7a] obtained a low concentration in the aqueous humor (0.1 mg. per hundred cubic centimeters) after frequent instillation of an 0.8 per cent solution of sulfanilamide. Rambo,[8] experimenting with intraocular injections into rabbits of concentrated sulfanilamide suspension, was able to prevent infection in three of four eyes subsequently inoculated with streptococci. The method, however, produced undesirable intraocular damage. P'an [9] obtained good concentration with sulfanilamide powder (aqueous humor, 54.8 ± 5.3 mg. per hundred cubic centimeters). Guyton [10] secured satisfactory concentrations with a 5 per cent sulfanilamide ointment (aqueous humor, 18.8 to 39.9 mg. per hundred cubic centimeters). He obtained inadequate concentrations, however, with a 5 per cent sulfapyridine (2-[paraaminobenzenesulfonamido]-pyridine) ointment (0.6 to 1.3 mg. per hundred cubic centimeters) and with a 5 per cent sodium sulfapyridine ointment (1.3 to 2.4 mg. per hundred cubic centimeters).

Clinical experiences with the local application of sulfathiazole in the eye have been reassuring but have suggested the use of a method that would produce a higher concentration.

The inability to produce an optimal concentration of sulfathiazole in the eye has encouraged further investigation. The iontophoretic method described here was undertaken in the hope of making this important bacteriostatic compound more efficient in ocular therapy. Iontophoresis has been used extensively in ophthalmology as a method of increasing the effectiveness of local therapy. Its routine clinical use abroad has led to several hopeful observations, although experimental proof of its superiority over other methods is scarce. It is not the purpose here to provide a review of the literature on iontophoresis. The articles of Schnyder,[11] Erlanger,[12] Karbowski [13] and Seech and Cooper [14] may be

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7a. Mengel, W. G.: Determination of Sulfanilamide in Aqueous and Vitreous After Conjunctival and Oral Administration, Arch. Ophth. **22**:406 (Sept.) 1939.

8. Rambo, V. C.: The Effects of Sulfanilamide as Determined in the Eyes of Rabbits, Am. J. Ophth. **21**:739, 1938.

9. P'an, S. Y.: Distribution of Sulfanilamide in the Ocular Fluids and Tissues After Local Application, Proc. Soc. Exper. Biol. & Med. **46**:31, 1941.

10. Guyton, J. S.: Local Use of Sulfanilamide Compounds in the Eye, Am. J. Ophth. **24**:292, 1941.

11. Schnyder, W. F.: Die Iontophorese in der Ophthalmologie, Klin. Monatsbl. f. Augenh. **63**:433, 1919.

12. Erlanger, G.: On the Scientific and Practical Value of Ionization in Ophthalmology, Brit. J. Ophth. **20**:213, 1936.

referred to for such a review. From the experimental data on the limited number of drugs reported it may be concluded that their intraocular concentration can be increased by iontophoresis.

The difficulty in quantitative estimation so often encountered with many of the drugs used in iontophoretic experiments is fortunately eliminated by the accurate methods of sulfathiazole determination.

TECHNIC

Sodium sulfathiazole is soluble in distilled water to the extent of 5 per cent, producing an almost isotonic although highly alkaline (p_H 10.5) solution. This was used at room temperature.

Anion electrolysis was used. A galvanic current was obtained from a 45 volt dry cell B battery (a 40 volt current being present throughout the experiments). The cathode consisted of a Birkhäuser [15] tube electrode constructed to conform to the size of the cornea of the experimental animals (rabbits were used throughout). The indifferent electrode was placed on the leg.

Controls consisted of corneal baths in which were used the same solution, apparatus and technic with the exception of the application of the electric current.

The concentration of free sulfathiazole in the cornea, aqueous humor and vitreous humor was determined by a modification of the method of Bratton and Marshall.[16]

The aqueous humor was removed immediately after enucleation by means of a 26 gage hypodermic needle attached to a ground glass fitting on a graduated capillary pipet. From 0.2 to 0.25 cc. was obtained and transferred directly to a 15 cc. centrifuge tube, diluted with 2 cc. of distilled water and the protein precipitated with 2 cc. of 15 per cent trichloroacetic acid.

The cornea was excised 1 mm. from the limbus, weighed in a covered glass weighing bottle and transferred to a glass mortar, where it was finely ground with ignited and washed quartz sand and 2 cc. of 15 per cent trichloroacetic acid for five to ten minutes, according to the procedure of Bellows and Chinn.[17]

The vitreous humor was removed after the aperture made by excision of the cornea was enlarged, and it was placed directly in a centrifuge tube. It was then weighed, 2 cc. of distilled water added and the protein precipitated with 2 cc. of 15 per cent trichloroacetic acid.

These solutions were centrifuged at 30,000 revolutions per minute for ten to fifteen minutes and the supernatant fluid decanted into a 10 cc. graduated test tube. The sediment was washed twice with 2 cc. of 15 per cent trichloroacetic acid,

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13. Karbowski, M.: Iontophoresis in Ophthalmology, Ophthalmologica **97**:166, 1939.

14. Seech, S. G., and Cooper, W. L.: Experimental Iontophoresis of Rabbits' Corneas, Arch. Ophth. **20**:624 (Oct.) 1938.

15. Birkhäuser, R.: Experimentelles und Klinisches zur iontophoretischen Behandlung von Hornhauttrübungen mit der Röhrenelektrode, Klin. Monatsbl. f. Augenh. **67**:536, 1921.

16. Bratton, A. C., and Marshall, E. K.: A New Coupling Component for Sulfanilamide Determination, J. Biol. Chem. **128**:537, 1939.

17. Bellows, J. G., and Chinn, H.: The Distribution of Sulfanilamide in the Eye, J. A. M. A. **112**:2023 (May 20) 1939.

and after centrifuging the washings were added to the test tube. All solutions were diluted to the 10 cc. mark and the free sulfathiazole determined by the colorimetric method of Bratton and Marshall.[16]

PROCEDURE AND RESULTS

In the preliminary experiments 0.5 per cent pontocaine hydrochloride solution was used in conjunction with pernoston solution (0.6 cc. per

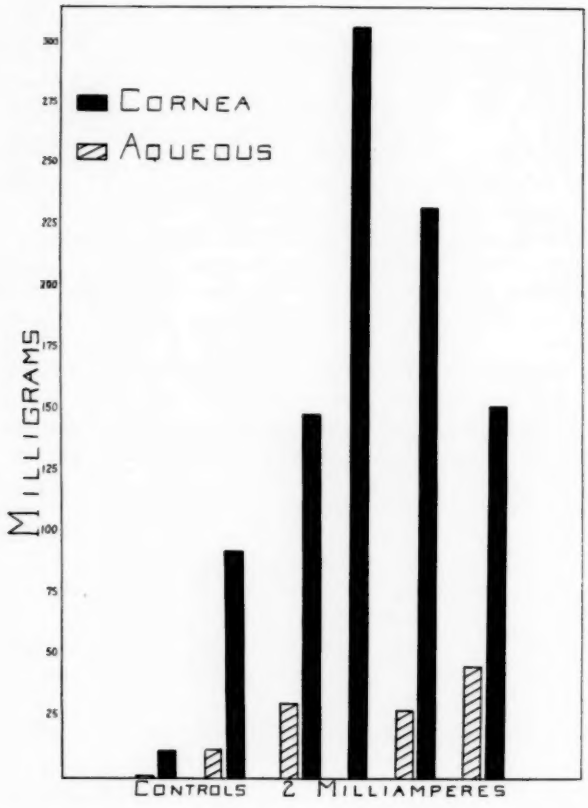

Chart 1.—Concentration of sulfathiazole in the cornea and in the aqueous after sodium sulfathiazole iontophoresis in the preliminary experiments (pontocaine anesthesia, 40 volts, five minutes). The concentration is given in all five charts as milligrams per hundred cubic centimeters.

kilogram) and supplemented by ether when necessary. A current of 2 milliamperes was applied for five minutes and the sulfathiazole concentration determined one-half to two hours later. Long and Wood [18] have

18. Long, P. H., and Wood, W. B., Jr.: Observations upon the Experimental and Clinical Use of Sulfapyridine, Ann. Int. Med. **13**:487, 1939.

shown that local anesthetics of this type produce a similar color reaction to that of sulfanilamide. This fact explains in part the erratic results secured (chart 1). In subsequent experiments satisfactory anesthesia was obtained with pernoston solution (0.65 cc. per kilogram) and ether. The most suitable time for enucleation was found to be one hour after iontophoresis.

To determine the optimum strength of current and time of application, these factors were varied independently. With a current of 2 milli-

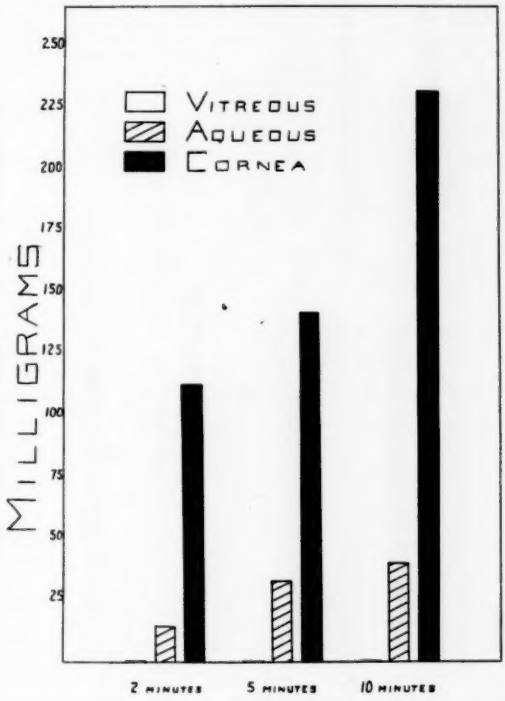

Chart 2.—Concentration of sulfathiazole in the vitreous, in the aqueous and in the cornea after sodium sulfathiazole iontophoresis with a current of 2 milliamperes.

amperes for two, five and ten minutes the concentrations in both the cornea and the aqueous humor varied directly but not proportionately with the application time (chart 2). With a variation in the strength of current of 1, 2, 3, 4 and 5 milliamperes and a constant application time (five minutes) there was again a direct but not proportional variation in the sulfathiazole content (chart 3).

A current over 3 milliamperes applied for more than five minutes produced macroscopic damage to the corneal epithelium. Succeeding

experiments were therefore limited to 1, 2 and 3 milliamperes applied for two and five minutes (charts 4 and 5). Each column in charts 4 and 5 represents the average of three to five individual experiments.

The average corneal concentration with an application time of two minutes and a current of 1 milliampere was approximately three times (38.8 mg. per hundred cubic centimeters) the average of the control experiments (11.6 mg.); similarly, with a current of 2 milliamperes it was approximately ten times (112.3 mg.) and with a current of 3 milliamperes approximately eleven times (117.8 mg.) that of the controls.

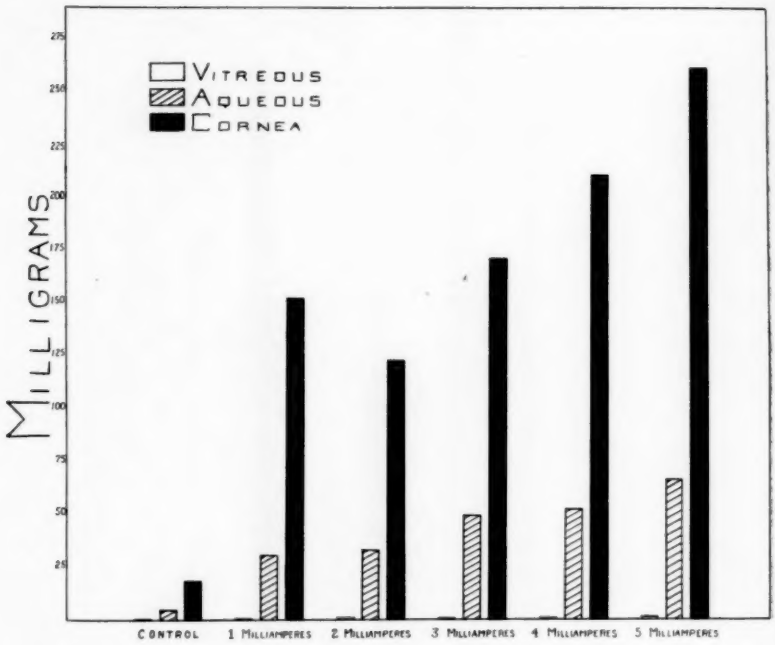

Chart 3.—Concentration of sulfathiazole in the vitreous, in the aqueous and in the cornea after sodium sulfathiazole iontophoresis with an application time of five minutes.

The average concentration in the aqueous humor with the same application time (two minutes) showed comparable increases over that in the control experiments, i. e. 1 milliampere approximately three times (6.5 mg.), 2 milliamperes approximately nine times (19.4 mg.) and 3 milliamperes approximately seventeen times (34.5 mg.) that of the controls (2 mg.).

With an application time of five minutes all concentrations were correspondingly increased (chart 5). The concentration in both the

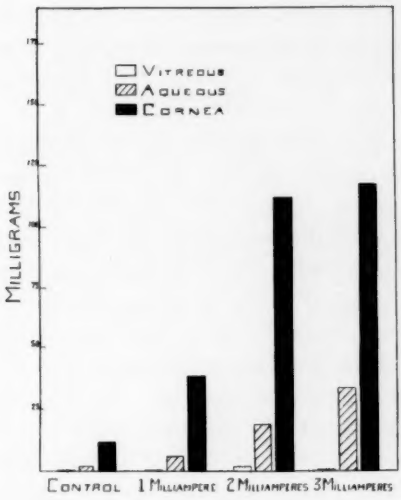

Chart 4.—Concentration of sulfathiazole in the vitreous, in the aqueous and in the cornea after sodium sulfathiazole iontophoresis with an application time of two minutes.

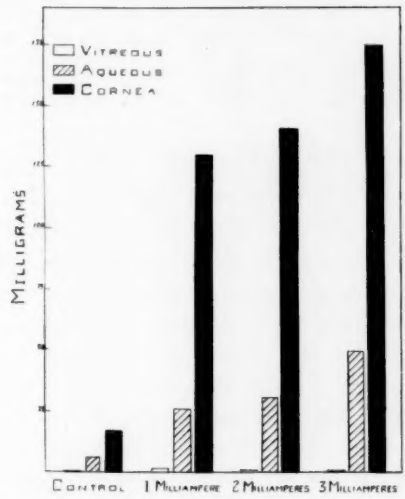

Chart 5.—Concentration of sulfathiazole in the vitreous, in the aqueous and in the cornea after sodium sulfathiazole iontophoresis with an application time of five minutes.

cornea and the aqueous humor, therefore, varied directly but not proportionately with both the strength of current and the time of application.

Sulfathiazole concentrations in the vitreous humor were too small and erratic to permit a similar comparison of the results.

COMMENT

Experimental iontophoretic application of sodium sulfathiazole produced a pronounced increase in the sulfathiazole concentration of the cornea and of the aqueous humor in comparison with the concentration obtained in the control experiments, in which no iontophoretic current was used. The strength of current and the application time showed general quantitative relation to the resultant sulfathiazole concentration, but this relation varied within certain limits in individual experiments. This was to be expected in view of the experiences with the iontophoretic introduction of other drugs.

The occasional bizarre results cannot be fully explained. They have been described in iontophoretic experiments in which other chemical compounds were used. However, individual variations in laboratory animals and unavoidable technical inconsistencies of temperature, anesthesia and the fitting of an electrode on the eyeball may interfere with the transmission of electrolytes.

No damage to the structures of the eyeball was noted with currents of 3 milliamperes or less applied for five minutes or less. Little vascular reaction was noted in the treated eyes, and those kept under observation for several days following treatment showed no apparent physiologic disturbance.

In nearly all eyes undergoing iontophoresis with sodium sulfathiazole the anterior portion of the embryonic lens suture became visible as a sharp grayish line. Zahn [19] described a similar phenomenon in the rabbit eye following anion iontophoresis of iodine. Erlanger [20] when employing cation iontophoresis encountered a comparable phenomenon. In the experiments reported here the condition was not only noted in eyes subjected to iontophoresis but occurred in certain of the control eyes exposed only to a corneal bath with sodium sulfathiazole. The change was transient, disappearing within an hour. It has not been described previously with either the clinical or the experimental use of sodium sulfathiazole. An explanation of this phenomenon would be purely speculative without further investigation.

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19. Zahn, E.: Experimentelle und klinische Erfahrungen mit der Ionentherapie, Klin. Monatsbl. f. Augenh. **48**:15, 1910.

20. Erlanger, G.: Die praktische und wissenschaftliche Bedeutung der Iontophorese in der Augenheilkunde, Concilium Ophth. **1**:196, 1929.

It may be concluded that it is not necessary to use an electric current stronger than 1 milliampere applied for a longer time than two minutes to obtain a satisfactory concentration of sulfathiazole in the cornea and in the aqueous humor. A current of 2 milliamperes, such as is frequently used in iontophoresis, produces a concentration of approximately 112 mg. per hundred cubic centimeters in the cornea and of 19.4 mg. in the aqueous.

In vitro experiments have shown that the bacteriostatic effectiveness of sulfanilamide and its derivatives varies directly with their concentration.[21] The iontophoretic application of sodium sulfathiazole, therefore, would appear to be indicated in the treatment of severe ocular infections caused by organisms susceptible to the bacteriostatic action of sulfathiazole.

CONCLUSIONS

1. Iontophoresis of a 5 per cent solution of sodium sulfathiazole with a low current (1 milliampere) for but a short time (two minutes) when compared with use of a corneal bath of equal duration increases the sulfathiazole concentration of the cornea and of the aqueous humor by three times. With a current of 2 milliamperes the concentration in the cornea and in the aqueous humor is ten and nine times, respectively.

2. Sulfathiazole concentrations varied directly but not proportionately with the strength of current and the time of application.

3. No ocular damage was observed with use of a current that produces a satisfactory sulfathiazole concentration in the cornea and in the aqueous humor—i. e. a concentration consistent with optimal bacteriostatic effect.

Dr. Ludwig von Sallmann provided criticism and suggestions throughout this work, and Miss Jeanette DiGrandi gave technical assistance.

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21. Chandler, C. A., and Janeway, C. A.: Observations on Mode of Action of Sulfanilamide in Vitro, Proc. Soc. Exper. Biol. & Med. **40**:179, 1939.

CONCEPT OF A ZONULAR CHAMBER

PRELIMINARY REPORT

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The anatomy of the vitreous and the lens is studied better in the gross than under the microscope because of the unavoidable artefacts produced in the preparation of the specimens for cutting sections.

All apparent discrepancies between the gross and the microscopic specimens must be reexamined until doubt is removed.

GROSS ANATOMY

After the lens-vitreous body is isolated in the fresh eye by removing the overlying structures in saline solution without pressure, it is suspended by a contact lens bulb applied to the anterior capsule. The retina and the vitreous hang by the zonular membrane from the lens.

When the retina is finally removed, the vitreous still hangs from the lens by means of the zonular membrane's insertion into the hyaloid membrane at the site of the ora serrata. This line of insertion may be called the hyaloretinal line (or ligament, since it represents the point of end action of the ciliary muscle).

In the eye of the calf the zonular membrane is particularly strong, and sutures taken in it produce when the specimen is suspended a hammock-like cradle in which the lens rests. The vitreous continues to hang from the hyaloretinal ligament. A similar procedure may be carried out with the human eye, except that the fibers break more readily, particularly in eyes from older subjects.

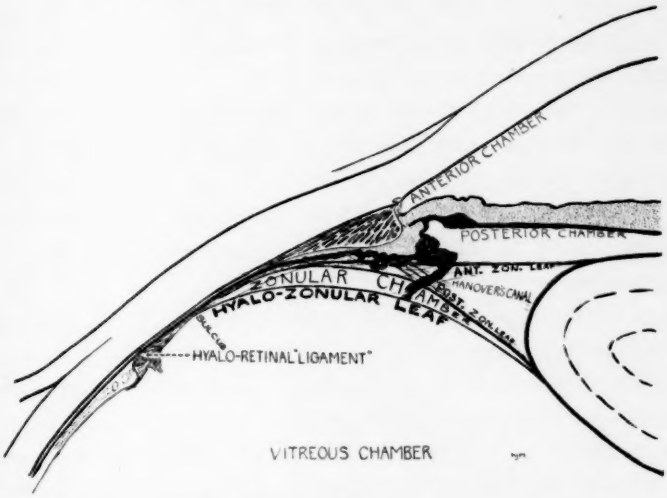
MICROSCOPIC ANATOMY OF THE ZONULAR MEMBRANE

In the accepted microscopic picture of the lens, zonular membrane and vitreous, there is no explanation for the vitreous' hanging from the zonular membrane, since the hyaloid membrane is supposed to be absent in the region of the base of the vitreous. The term "zonular cleft" is a misnomer even though Salzmann stated that there is no space but rather thickened vitreous (the base of the vitreous). He might have used a term like zonular wedge or thickening. This I prefer to the term hyaloretinal ligament.

From the service of Dr. Kaufman Schlivek, Mount Sinai Hospital. The major part of the microscopic work was done at the New York Eye and Ear Infirmary under the supervision of Dr. Bernard Samuels.

A restudy of the microscopic picture does not contradict the observations of gross dissection. When certain constant findings are properly emphasized, a revaluation results in the microscopic picture's explaining the gross.

In addition to the classic anterior zonular leaf and posterior zonular leaf, which bound Hannover's canal at the equator of the lens and run along the valleys and sides of the ciliary processes, another leaf is found on the anterior surface of the hyaloid membrane. This leaf, which may be named the hyalozonular leaf, contains "the few innermost zonular fibers" of Salzmann and has not been properly described before. Three reasons may be advanced for its previous obscurity: 1. Being intimately attached to the hyaloid membrane, the fibers are lost in the distortions



Diagrammatic presentation of the zonular membrane, showing the relations of the zonular chamber. The posterior zonular leaf is equivalent to the "innermost fibers" of Salzmann, which have not been fully evaluated heretofore. The word sulcus is used for want of a better term and represents a flattening of the posterior zonular leaf just beyond the angle of the zonular chamber.

resulting from alterations in the vitreous during the preparation of the specimen. 2. As they spring from the ciliary epithelium, they are too readily confounded with the fibers of the other two leaves. 3. The massive insertion of the zonular membrane into the unfixed vitreous was not fully appreciated, since the demonstration of the fresh vitreous hanging from the zonular membrane had not been made.

The hyalozonular leaf has an insertion in the posterior capsule of the lens independent from that of the posterior zonular leaf, with which it

forms a sharp acute angle. It arches over the face of the vitreous to reach a point midway between the ora serrata and the posterior tips of the ciliary processes. Here a sulcus of closely packed stretched-out fibers receives strands from the other two leaves. The fibers then fan out like a brush. Most of the fibrillae traverse the hyaloretinal ligament to reach the ciliary epithelium and the ora serrata and the angle formed by them. Some of the fibers bend to enter the vitreous adjacent to its "base," and others occasionally go even beyond the ora serrata.

The zonular membrane, therefore, may be considered as being made up of three leaves: (1) the anterior zonular leaf, (2) the posterior zonular leaf and (3) the hyalozonular leaf.

THE ZONULAR CHAMBER

Between the hyalozonular leaf and the other two leaves of the zonular membrane, an actual space is present in life. It is bounded in front by the posterior surface of the combined anterior and posterior leaves, in back by the anterior surface of the hyalozonular leaf, centrally by the angle formed by the hyalozonular leaf and the posterior zonular leaf and peripherally by the insertion of the hyalozonular leaf into the ciliary epithelium. Both the anterior leaf and the posterior leaf give off fibers which go to the hyalozonular leaf.

When Petit demonstrated the canal named after him, either he produced an artefact between the hyaloid membrane and the hyalozonular leaf, or he unknowingly broke through the latter to inflate the intrazonular space described in this report.

The proof of the existence of this intrazonular space lies in the fact that it can be injected with carmine or other dye. The preparation of the anterior half of the eye is made so as to include the vitreous. After the hypodermic needle is placed in the suprachoroid space and passed through the ciliary body just beyond the posterior tips of the ciliary processes, it appears anterior to the hyalozonular leaf. When injected at any one point, the carmine fills this chamber and outlines it as a circular channel, or sinus, which is sharply limited peripherally by a wavy line midway between the ora serrata and the posterior tips of the ciliary processes. From its central, or anterior, border this channel communicates with the circumlental space by linear canals running in the valleys of the ciliary body. Almost with the beginning of the injection, the anterior chamber starts to fill up, this fact indicating that there is a free communication by way of the lesser posterior chamber (or Hannover's canal or both).

Further proof of this concept is to be seen in slides of eyes with pathologic conditions in which serum, blood, exudate or casts are seen confined in this intrazonular space, partially filling it and assuming its shape. In hydrophthalmos and in glaucoma the zonular chamber is dilated.

It is suggested that this space be called the zonular chamber because it is entirely within the zonular membrane. Accordingly, the eye would be described as having five chambers: (1) the anterior chamber, (2) the posterior chamber, (3) Hannover's canal, (4) the zonular chamber and (5) the vitreous chamber.

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TRAUMATIC MYOPIA WITH HYPOTONY

REPORT OF TWO CASES WITH REVIEW OF THE LITERATURE

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The two clinical entities traumatic myopia and traumatic hypotony have been known to ophthalmologists for a long time. As early as 1870 Kugel [1] reported decidedly increased refraction in the injured eyes of 2 soldiers as the result of mechanical trauma, and in 1876 Heimann [2] reported 7 cases of ocular hypotony, in 2 of which he ascribed the condition to contusion of the globe.

The presence of hypotony in cases of traumatic myopia also has been noted by Schiess-Gemuseus,[3] Laws,[4] Fromaget,[5] Bailey,[6] Robinson,[7] Moller,[8] Damel [9] and others. Magitot,[10] especially, has written extensively on both subjects. It is noteworthy, however, that despite the identity of the causation and the frequently noted occurrence of the two

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1. Kugel, L.: Ueber acute Entwicklung der Myopie, Arch. f. Ophth. **16**:323, 1870.

2. Heimann, A.: Weitere Beiträge zur Kenntnis der vasomotorischen und secretorischen Neurosen des Auges, Arch. f. Augenh. **5**:303, 1876.

3. Schiess-Gemuseus, H.: Traumatische Myopie, langsame spontane Restitution, Klin. Monatsbl. f. Augenh. **19**:384, 1881.

4. Laws, W. G.: A Case of Temporary Myopia Following a Blow on the Eye, Ophth. Rev. **16**:204, 1897.

5. Fromaget, C.: Deux cas de myopie traumatique par advancement du cristallin, Bull. et mém. Soc. franç. d'opht. **28**:346, 1911.

6. Bailey, J. H.: Traumatic Myopia, Am. J. Ophth. **4**:363 (May) 1921.

7. Robinson, J.: Traumatic Myopia, Am. J. Ophth. **8**:654 (Aug.) 1925.

8. Moller, H. U.: Vorübergehende traumatische Myopie mit Glaskörpervorfall in die Vorderkammer, Acta ophth. **4**:60, 1926.

9. Damel, C. S.: Myopia traumática, Arch. de oftal. de Buenos Aires **8**:497 (Nov.) 1933.

10. Magitot, A.: (*a*) Sur quelques variations traumatiques de la tension oculaire, Ann. d'ocul. **154**:667 (Nov.) 1917; (*b*) Quatre cas de myopie traumatique, ibid. **157**:680, 1920; (*c*) Sur quelques variations traumatiques de la tension oculaire, ibid. **155**:1, 1918; (*d*) Deux types de modifications traumatiques de la tension oculaire, ibid. **155**:66, 1918; (*e*) Réactions croisées oculo-oculaires, ibid. **170**:465 (June) 1933; (*f*) Hypotensions oculaires pathologiques, ibid. **173**:785 (Oct.) 1936.

conditions in the same case, there are not many detailed reports in the ophthalmic literature describing the prolonged coexistence of traumatic myopia with hypotony.

TRAUMATIC MYOPIA

Following Kugel,[1] reports on traumatic myopia accumulated rapidly. In 1871 Aub [11] reported 1 case and Manfredi [12] 2, and in 1872 Just [13] reported another. By 1905 Frenkel [14] was able to collect 41 published cases and add 2 of his own. Since then I have found 60 more cases [15] reported in the literature. Several others may have escaped my attention.

From the first it was evident that traumatic myopia is not a single, clearcut clinical picture and that from the point of view of type of external trauma, duration and internal damage sustained cases of traumatic myopia can be divided into several groups.

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11. Aub, J.: Beiträge zur Kenntnis der Verletzungen des Augapfels und seiner Umgebung, Arch. f. Augen- u. Ohrenh. **2**:252, 1871.

12. Manfredi, N.: Due casi di lussatione del cristallino e contribuzione della teoria sul mecanismo dell' accommodazione, Ann. di ottal. **1**:189, 1871.

13. Just, O.: Traumatischer Accommodationkrampf, Klin. Monatsbl. f. Augenh. **10**:256, 1872.

14. Frenkel, H.: Étude sur les myopies traumatiques, Ann. d'ocul. **134**:1, 1905.

15. (*a*) Pooley, T. R.: Transient Myopia Due to Trauma, Tr. Am. Ophth. Soc. **11**:120, 1906. (*b*) Sourdille, G.: La myopie traumatique, Gaz. méd. de Nantes **46**:945, 1908. (*c*) Ralston, W.: Report of a Case of Transient Myopia of Traumatic Origin, Texas M. J. **5**:266, 1909-1910. (*d*) Majewski, K. W., in discussion on Fromaget,[5] p. 357. (*e*) Tange, A.: Myopie traumatique, abstracted, Arch. d'opht. **34**:463, 1914. (*f*) Terrien, F.: Astigmatisme et contusion du globe oculaire, ibid. **35**:689, 1917. (*g*) Frenkel, H.: Étude sur le syndrome traumatique du segment antérieur de l'oeil, Ann. d'ocul. **155**:78, 1918. (*h*) Paparcone, E.: Diplopia monoculaire e miopia traumatica; abstracted, Boll. d'ocul. **1**:76, 1922. (*i*) Salzmann, M.: Ueber die Sichtbarkeit der Ora serrata, die Ablösung dieser Gegend und die traumatische Myopie, Verhandl. d. ausserord. Tag. d. ophth. Gesellsch. (1921), 1922, p. 416. (*j*) Grandclément, L.: Un cas de myopie traumatique, Lyon méd. **131**:221, 1922. (*k*) Matsuoka, H.: Ein Fall von traumatische Myopie nach Absturz mit dem Flugzeuge, Zentralbl. f. d. ges. Ophth. **26**:529, 1931-1932. (*l*) Brons, J.: Traumatische Myopie mit folgendem Glaukom, ibid. **25**:534, 1931. (*m*) Bolotte: Myopie traumatique, Arch. d'opht. **51**:622 (Oct.) 1934. (*n*) Sgrosso, S.: La miopia traumatica e la sindrome traumatica del segmento anteriore di Frenkel, Boll. d'ocul. **13**:433 (April) 1934. (*o*) Janson, E.: Ueber traumatische Myopie, Klin. Monatsbl. f. Augenh. **94**:517 (April) 1935. (*p*) Marucci, L.: Quattro casi di miopia traumatica, Rassegna ital. d'ottal. **5**:327 (May-June) 1936. (*q*) Cosserat: Trois cas de myopie traumatique, Soc. de méd. mil. franç., Bull. mens. **32**:526 (Dec.) 1938. (*r*) Dejean, C., and Guignot, R.: A propos d'un cas de myopie traumatique: Considérations médico-légales, Arch. Soc. d. sc. méd. et biol. de Montpellier **19**:73 (Feb.) 1938. (*s*) Morgan, O. G.: Some Cases of Traumatic Myopia, Brit. J. Ophth. **24**:403 (Aug.) 1940. (*t*) Fromaget.[5] (*u*) Bailey.[6] (*v*) Robinson.[7] (*w*) Moller.[8] (*x*) Damel.[9] (*y*) Magitot.[10a] (*z*) Magitot.[10b]

Type of Trauma.—Since this discussion is confined to mechanical trauma, there are two types to be considered: (1) contusions and (2) penetrating wounds. The majority of reported cases of traumatic myopia are instances of contusion or concussion myopia, and rarely is there a report of scleral rupture. This is probably due mainly to the fact that when the rupture is large the damage to the eye is so great and the vision so poor that refraction is difficult to check. Secondly, slight penetrating wounds and small foreign bodies are often difficult to see and may be overlooked. However, Magitot [10a] has shown that in cases of a small scleral rupture or intraocular foreign body the resultant myopia is not due to the scleral tear and the eye acts exactly like an eye which has sustained a concussive injury.

Duration.—Traumatic myopia may last from one day (Bailey [6]) to over thirty years (Janson [15o]). In most cases it is transient and clears up at least within a month or two, usually much sooner. Thus in Laws's [4] and Moller's [8] cases it lasted five days, in Fromaget's [5] case fourteen days, in Damel's [9] sixteen days, in Pooley's [15a] eighteen days, in Aub's [11] twenty-four days, in Bolotte's [15m] one month and in Brons's [15l] two months. In 8 of Janson's [15o] 9 cases refraction returned to normal within a month, and in Marucci's [15p] 4 cases the condition cleared up in six weeks.

However, there is another well defined though smaller group of cases of traumatic myopia in which the duration is longer. Thus Fromaget [5] and Morgan [15n] reported cases in which the myopia lasted a year, von Grolman [16] a case in which it lasted a year and a half and Sourdille [15b] a case in which it lasted three years. In an even smaller group of cases, the myopia seems to be of a permanent character, as reported by Majewski,[15d] Janson [15o] and Bourgeois,[17] among others.

Why this difference in duration? The answer is apparently tied up with the fundamental etiologic factor, i. e. with the amount and the kind of damage sustained by the eye internally.

Etiologic Theories.—Kugel [1] and later Laws [4] and Risley [18] attributed the myopia in their cases to lengthening of the anteroposterior axis of the globe. Moller,[8] Just,[13] Paparcone,[15h] von Grolman [16] and others explained the myopia in theirs by postulating accommodative spasm. Schiess-

16. von Grolman: Ein merkwurdiger Fall von traumatische Myopie, Ztschr. f. prakt. Aerzte **5**:287, 1896.

17. Bourgeois: Myopie traumatique par propulsion du cristallin en avant, Ann. d'ocul. **132**:267 (Oct.) 1904.

18. Risley, S. D.: Increasing Refraction Following Increased Tension of the Globe, Therap. Gaz. **41**:157, 1917.

Gemuseus,[8] Damel,[9] Aub,[11] Salzmann,[15i] Darier,[19] Guende [20] and many others held relaxation or a tear of the zonule with consequent forward movement of the lens responsible. Manfredi,[12] Majewski,[15d] Bourgeois [17] and others found an anterior dislocation of the lens to explain the myopia in their cases.

Frenkel [14] was apparently the first to bring some order into the picture by his classification of traumatic myopia into four main types:

1. Spasmodic myopia due to accommodative spasm. This is characterized by nearing of the far point, loss of accommodative amplitude, possible miosis and disappearance of the myopia with the use of atropine. This type offers the best prognosis.

2. Relaxation of the lens zonule. The pupil is dilated and reacts poorly, the anterior chamber may be shallow and atropine is ineffective. Physostigmine may effect a cure if there is increased tension. This type heals either more slowly than the first or not at all.

3. Subluxation or total dislocation of the lens forward. Iridodialysis, hyphemia and rupture of the choroid are frequent.

4. Lengthening of the axis of the eye due to inflammation of the posterior segment. This type is rare.

According to Frenkel cure is possible only in the first two classifications, with type 1 offering the best prognosis. In similar vein Sulzer [21] called the first two types "false," or transient, myopia to distinguish them from the permanent, or "true," traumatic myopia of the last two types.

Most subsequent writers have accepted Frenkel's classification. There seems to be general agreement that the transient traumatic myopia of short duration which responds to atropine is the spasmodic myopia of Frenkel's type 1. The cases of Terrien,[15f] Paparcone,[15h] Bolotte,[15m] Janson,[15o] Morgan [15s] and numerous others were instances of this type. The mechanism is apparently one of traumatic irritation causing ciliary spasm not unlike the chemical or toxic ciliary spasm reported after the use of arsenic by Milian and Périn,[22] Milian,[23] Jean-Sédan [24] and others;

19. Darier, A.: De la myopie traumatique par distension ou déchirure de la zonule, Clin. opht. **5**:85, 1899.

20. Guende, C.: La myopie traumatique par distension de la zonule de Zinn, Marseille-méd. **37**:449 (Aug.) 1900.

21. Sulzer, M., in Lagrange, F., and Valude, E.: Encyclopédie française d'ophtalmologie, Paris, Octave Doin, 1904, vol. 3, p. 331.

22. Milian, G., and Périn: Arsphénamin-myopie, Paris méd. **2**:388 (Nov. 12) 1921.

23. Milian, G.: Paralysie arsénicale de l'accommodation, Rev. franç. de dermat. et de vénéréol. **6**:349, 1930.

24. Jean-Sédan: Myopie spasmodique transitoire stovarsolique, Rev. d'oto-neuro-opht. **17**:112 (Feb.) 1939.

after the inhalation of arsenic fumes by Roggenkamper [25]; after the use of sulfanilamide and its derivatives by Gailey,[26] Bristow,[27] Hornbogen [28] and a host of others during the past three years; in association with iritis by Green,[29] de Schweinitz [30] and many others, and in association with many other general toxic disturbances. Renard [31] reported a case of transient myopia lasting nine days which he ascribed to ciliary spasm excited by an acute chalazion.

In those cases of traumatic myopia of longer duration in which there is little or no diminution of the myopia after the use of atropine the condition is generally attributed to zonular relaxation or injury with forward displacement of the lens. For, as Salzmann [15l] has pointed out, it is more logical that trauma should cause a weakening in the neighborhood of the zonule than that it should cause a spasm of the ciliary muscle in such cases. And Janson [15o] attributed prolonged traumatic myopia in some cases to hyperemia and edema of the ciliary muscle as well as to weakening and tearing of the zonule. The cases of Damel,[9] Ralston,[15e] Matsuoka,[15k] Cosserat,[15q] Guende [20] and numerous others were of this group.

The myopia in such cases as those of Majewski,[15d] Janson [15o] and Bourgeois,[17] in which an anterior dislocation of the lens was evident, is self explanatory. These cases need little discussion and can be grouped as instances of the third type of traumatic myopia in Frenkel's classification.

Cases of type 4 traumatic myopia have been reported so rarely that this classification is accepted by default so to speak. Kugel [1] explained his case—one of the few fitting into this class—by a weakening of the scleral tissues due to inflammatory processes and consequent lengthening of the anteroposterior diameter of the bulb. A somewhat similar explanation was given by Risley,[18] who reported a case of increased refraction due to thinning of the sclera and actual elongation of the eyeball following increased tension of the globe.

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25. Roggenkamper: Transitorische Myopie nach Verletzung durch Hochofenschlacke, Klin. Monatsbl. f. Augenh. **86**:239, 1931.

26. Gailey, W. W.: Transient Myopia from Sulfanilamide, Am. J. Ophth. **22**:1399 (Dec.) 1939.

27. Bristow, J. H.: Temporary Myopia Due to Sulfanilamide, Arch. Ophth. **24**:799 (Oct.) 1940.

28. Hornbogen, D. P.: Transient Myopia During Sulfanilamide Therapy, Am. J. Ophth. **24**:323 (March) 1941.

29. Green, J.: On a Transient Myopia Occurring in Connection with Iritis, Tr. Am. Ophth. Soc. **4**:599, 1887.

30. de Schweinitz, G. E.: Diseases of the Eye, ed. 10, Philadelphia, W. B. Saunders Company, 1924.

31. Renard, G.: Myopie spasmodique transitoire avec myosis à la suite d'une infection de la paupière, Rev. d'oto-neuro-opht. **9**:216, 1931.

Thus in most cases traumatic myopia falls into one of these four main types. In some cases, however, it is not so easily allocated. For instance, in von Grolman's [16] case the myopia, attributed to accommodative spasm and responsive to atropine, lasted for one and one half years. Surely this was not a case of transient myopia as the word transient is understood. In Damel's [9] case, on the other hand, the myopia lasted only sixteen days and showed not the slightest response to atropine. In 1 of Magitot's [10b] cases ciliary spasm responded neither to atropine, general anesthesia nor paracentesis. Morgan [15s] reported a case of traumatic myopia which lasted almost a year. At first he explained the condition by ciliary spasm, but later he had to add "some subconscious functional element." Tange,[15e] also, in his case connected prolonged ciliary spasm with hysterical symptoms. Then there are the cases of Moller,[8] Cosserat [15q] and others, in which the myopia, attributed to zonular weakening or rupture, disappeared but iridodonesis remained. These and similar cases which do not fall neatly into any single one of Frenkel's types have stimulated much etiologic speculation.

Thus Robinson [7] attributed the myopia in his case simply to a swelling of the lens, and Bailey [6] suggested the possibilities of increased corneal curvature due to injury to Descemet's membrane and an alteration in the composition of the aqueous. Morgan [15s] suggested that swelling of the vitreous or a change in the refractive power of the media may cause myopia. Bouchart [32] said that swelling of the vitreous or distention of the zonule may be the etiologic agent. He suggested in addition that an increase in the anteroposterior diameter of the eye may be due to choroidal tears. One of Janson's [15o] patients, however, had choroidal tears, but the myopia lasted only four days. Bourgeois [17] stated the belief that mechanical trauma may force the aqueous into the posterior chamber and the perilental space, thus causing a forward movement of the lens.

Others, notably Bolotte [15m] and Dejean and Guignot,[15r] have inclined to Hudelo's [33] theory of accommodation to explain at least some cases of traumatic myopia. According to this theory Brücke's muscle is the radial portion of the ciliary mechanism, supplied by the sympathetic system and acting anteroposteriorly by pulling the vitreous forward and thus flattening the lens. This causes a diminution of refractive power and facilitates distant vision. On the other hand, the circular Rouget-Muller muscle, supplied by the third cranial nerve, causes a swelling of

32. Bouchart, A.: Des mécanismes comparés de la myopie traumatique et de l'accommodation, Thesis, Lyon, no. 38, 1898; La contusion oculaire et la refraction, Rec. d'opht. **23**:1 (Jan.) 1901.

33. Hudelo, A.: Mécanisme de l'accommodation et myopie diabétique, Arch. d'opht. **47**:70 (Feb.) 1930.

the lens when it contracts and thus acts in accommodation for near vision. According to this theory transitory myopia is due to a paralysis of the radial fibers which leaves the circular portion of the ciliary muscle free to cause swelling of the lens, with an increase in refraction. Hudelo is not the only one to argue for a dual accommodative mechanism. Henderson,[34] Nicati [35] and Noiszewski,[36] among others, have also been its proponents. On the other hand, Terrien [37] and Terrien and Camus [38] have shown that an increase in refraction can be obtained by stimulation, not paralysis, of the sympathetic system.

Schiess-Gemuseus [3] argued that a lack of production of aqueous would account at least in part for narrowing of the anterior chamber and advancement of the lens. Later Laws,[4] Fromaget [5] and Grandclément [18j] offered a similar explanation for traumatic myopia in their cases.

TRAUMATIC HYPOTONY

Traumatic diminution in tension occurs much more frequently than reports in the literature would indicate. Frenkel [15g] and Marín Amat [39] stated the belief that it occurs more commonly than hypertension after trauma. Magitot [40] stated that either hypertension or hypotension may appear after trauma and stressed the variability of the ocular tension as an important feature following contusions.

As in the case of the traumatic myopias, though to lesser degree, the traumatic hypotonies may be classified according to type of trauma and duration:

Type of Trauma.—Magitot [10f] and Duke-Elder [41] listed two main types:

1. Perforating wounds with loss of intraocular contents. The immediate resultant hypotony is self explanatory.

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34. Henderson, T.: The Postural Activity and Evolution of the Ciliary Muscle in Mammalia: A Study of the Mechanism of Accommodation, Tr. Ophth. Soc. U. Kingdom **45**:521, 1925.

35. Nicati, W.: Physiologie oculaire; humaine et comparée, normale et pathologique, Paris, Schleicher frères, 1909.

36. Noiszewski, K.: Accommodation pour la vision des objets eloignés. La mécanisme hydraulique de l'accommodation, Arch. d'opht. **47**:601 (Sept.) 1930.

37. Terrien, F.: Des complications oculaires après emploi des arsénobenzols, Arch. d'opht. **46**:513 (Sept.) 1929.

38. Terrien, F., and Camus, J.: Influence de l'excitation du sympathétique cervical sur l'ensemble de la refraction de l'oeil, Compt. rend. Soc. de biol. **54**:579, 1902.

39. Marín Amat, M.: Dos casos de alteraciones traumáticos de la tension ocular de hiper- e hipotension respectivamente, Siglo méd. **94**:148, 1934.

40. Magitot (footnote 10 *c* and *d*).

41. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1941, vol. 3.

2. Concussion. Hypotony from concussion has been reported by Magitot,[42] Marín Amat,[39] Leplat,[43] Collins,[44] Collins and Hinnel,[45] Manes [46] and many others.

To these may be added a third, intermediate type, in which there is perforation of the globe but of insufficient size to permit the escape of intraocular contents. This type has been described clinically by Magitot [10a] and experimentally by Weekers.[47] With it may be placed partial scleral rupture through the pectinate ligament or the canal of Schlemm or both, as reported by Collins [44] and Fuchs.[48] Both Magitot [10a] and Duke-Elder [41] have pointed out, however, that clinically this type may be indistinguishable from the first.

Duration.—Traumatic hypotony may be so transient as to disappear overnight. In October 1941 I saw a clinic patient with a tension of 8 (Schiøtz) immediately after a blow to the left eye. The following day the tension was 22. Magitot [10a] has reported cases in which the hypotony lasted four, nine, fourteen and twenty-five days. In Manes' [46] case it lasted twenty-five days and in Marín Amat's [39] case forty days. On the other hand, the hypotony was still 2 minus ten months after the accident in the case of Collins and Hinnel [45] and one year after the accident in Fromaget's [5] case.

In all these cases the trauma was apparently a contusion injury with no discoverable external rupture of the globe, yet the duration varied decidedly. Hence with traumatic hypotony, unlike traumatic myopia, it is more difficult to prognosticate duration on the basis of the type of trauma. Collins,[44b] it is true, has attempted to classify contusion hypotony into (1) that of short and (2) that of long duration. He said that the former may be due to an increase in the excretion of aqueous through expanded normal channels or to an arrest of secretion. The hypertony of longer duration he ascribed to the possible formation of new excretory channels by internal rupture or to the cutting off of the

42. Magitot (footnote 10 *a* and *b*).

43. Leplat, L.: De la contusion du globe oculaire, Ann. d'ocul. **103**:209 (May-June) 1890.

44. Collins, E. T.: (*a*) On the Pathological Examination of Three Eyes Lost from Concussion, Tr. Ophth. Soc. U. Kingdom **12**:180, 1891-1892; (*b*) Contusion Hypotony, ibid. **36**:204, 1916.

45. Collins, E. T., and Hinnel, J. S.: Diminished Tension and the Appearance of Optic Neuritis Persisting for Nine Months After a Wound of the Orbit by a Shot from an Air-Gun, Tr. Ophth. Soc. U. Kingdom **21**:100, 1901.

46. Manes, A. J.: Hipertonias e hipotonias agudas, Rev. Asoc. méd. argent. **46**:883 (Aug.) 1932.

47. Weekers, L.: Réactions ophtalmotoniques expérimentales par piqûre du corps ciliare, Arch. d'opht. **49**:24 (Jan.) 1932.

48. Fuchs, E.: Ueber innere Skleralruptur, Arch. f. Ophth. **79**:53, 1911.

blood supply to the ciliary arteries by rupture of the anterior ciliary veins. Subsequent writers, however, have not adopted such a classification.

Etiology.—There is more unanimity as to the etiologic factor of traumatic hypotony than as to that of traumatic myopia. Most authors agree that the hypotony is due to some kind of interference with the normal circulation of aqueous, although there is disagreement as to how this occurs. Heimann [2] expressed the opinion that it is due to an innervational disturbance of the intraocular secretion, and Leplat [43] attributed it to sympathetic paralysis of the fibers controlling production of the intraocular fluids. Collins,[44b] as shown previously, stated the belief that hyposecretion, hypersecretion or both may be involved. Lagrange [49] attributed traumatic hypotony to nervous inhibition of the production of aqueous, but Parsons [50] favored direct injury to the secretory apparatus rather than paralysis of the nervous mechanism. In fact, Parsons [51] stated the belief that there are no special nerves for the secretion of intraocular fluids and that the action is through the blood vessels themselves. Marín Amat [39] suggested that hypotension may be due to spasm of the muscle fibers of the uveal vessels, diminution in their permeability and consequent ischemia.

Magitot,[40] who found hypertony preceding traumatic hypotony in every case, no matter how fleeting the condition, argued for an interconnected regulatory mechanism probably located in the choroid of each eye. This mechanism, which ordinarily regulates the tonus of the eye, is disorganized by trauma, he said. The result is an increase or decrease in tonus, with a consequent increase or decrease in ocular tension. He also advanced the possibility of an accelerated rhythm of excretion of aqueous after contusion, due probably to the speeding up of the venous current, as shown by Weekers.[47] Leplat [43] not only suggested a diminution in the secretion of aqueous due to sympathetic paralysis but argued for actual shrinkage of the vitreous as a possible etiologic factor. Schmidt and de Decker [52] and Poos [53] showed that experimental ocular hypotony is attended by injury to the capillaries and argued that traumatic hypotony may be of similar origin.

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49. Lagrange, F.: L'hypotonie oculaire, ses causes, ses dangers, son traitement, Bull. Soc. d'opht. de Paris **5**:81 (Feb.) 1927.

50. Parsons, J. H.: Pathology of the Eye, London, Hodder & Stoughton, 1908, vol. 4, p. 1147.

51. Parsons,[50], vol. 3, p. 982.

52. Schmidt, K., and de Decker, J. F.: Experimentelle Untersuchungen über Prellungshypotonie beim Kaninchen, Arch. f. Augenh. **102**:700, 1930.

53. Poos, F.: Ueber die drucksenkenden Faktoren bei der sog. osmotischen Hypotonie, Klin. Monatsbl. f. Augenh. **89**:145 (Aug.) 1932.

In most of the reports mentioned, therefore, the disturbance of normal intraocular secretion is stressed as an etiologic factor rather than the traumatic increase of avenues of egress to the aqueous. Collins,[44a] one of the chief proponents of the theory of a traumatic increase of channels for the excretion of aqueous, has, however, offered excellent evidence for his theories. A pathologic study of 3 eyes enucleated after traumatic hypotony with no external perforation showed tearing across the pectinate ligament, splitting of the ciliary muscle and prolongation of the anterior chamber outward. He pointed out that rupture of the pectinate ligament can be diagnosed clinically by a deep anterior chamber, hyphemia and localized retraction of the iris. Fuchs [48] was able to identify incomplete scleral rupture clinically by a bluish black line near to and concentric with the limbus due to adhesions of the iris to the internal tear. In most cases of traumatic hypotony, however, such external signs are absent.

Later Collins [44b] agreed that hypotony after contusion is due to different causes and that more than one may be present. He also denied the suggestion that hypotony after contusion is due to an indirect rupture of the posterior part of the globe which cannot be seen clinically. His pathologic studies never disclosed such a tear. It might be added here that work as yet unpublished convinces me that a large incision of the posterior part of the sclera and even excision of a large scleral section from the back of the globe does not necessarily cause a permanent reduction in tension. And Nettleship [54] has commented significantly that ". . . it was of practical interest to know that in a case in which the tension was found to be minus shortly after a violent indirect injury to the eye, we need not now assume that the lowered tension necessarily meant wound or rupture of the globe."

COMMENT

Hypotony is not a necessary concomitant of traumatic myopia. In 16 of the cases collected by Frenkel [14] the tension was reported, and there was a decrease in only 4. In 7 there was an increase, and in the rest the tension was normal. Marucci [15p] reported hypertension in 1 of his 4 cases of traumatic myopia. On the whole, however, the existence of hypertony with traumatic myopia is relatively rare, and coexisting hypotony is reported much more frequently in the literature.

Even more rare are reports of hypermetropia with hypotony, at least in concussive injuries. As far as I have been able to discover, only Leplat [43] has reported cases of such an association. In fact, he

54. Nettleship, in discussion on Collins and Hinnel.[45]

and Huber [55] seem to be among the few who have reported a decrease in refraction following trauma. The latter did not report the presence of hypotony in his 3 cases and was at a loss to explain the decrease in refraction.

The frequent coincidence of traumatic myopia and hypotony is of etiologic significance. In view of the generally accepted belief that traumatic hypotony is due to some interference with the production of aqueous, it seems possible that this theory may explain at least some of the more unusual cases of coexisting traumatic myopia which does not fit into either of Frenkel's first two types.

As a matter of fact, Collins [56] has suggested that hypotony may cause myopia by producing a slackening of the suspensory ligament and a forward displacement of the lens. Laws [4] in his case explained the myopia in the presence of hypotony by an increase in the antero-posterior axis of the eye brought about by compression of the softened eye by the surrounding muscle sheath. Fromaget [5] reported a case of traumatic myopia with hypotony and abolition of the anterior chamber with complete recovery in fourteen days when the anterior chamber was restored. He attributed the hypotony and myopia to lack of production of aqueous. Grandclément [151] reported a similar case and ascribed the condition to a similar cause. And it is of interest to note that among Leplat's [43] cases of hypermetropia associated with a deep anterior chamber, in the only case of transient myopia the anterior chamber was not deep. Knapp [57] described a case of traumatic myopia with abolition of the anterior chamber in which transient glaucoma developed as soon as the anterior chamber was reformed, and Brons [151] reported a similar case. The increased tension in these 2 cases may reasonably be ascribed to a sudden resumption of the formation of aqueous with temporary embarrassment of the normal excretory channels of the eye.

Hence the lack of production of aqueous has been frequently noted, and its etiologic role in both traumatic myopia and traumatic hypotony has already been suggested. In some cases of temporary traumatic myopia with forward displacement of the lens the interference with the secretion of aqueous seems to offer a more acceptable clinical explanation than the theory of accommodative spasm or zonular injury or any combination of speculative theories. This theory seems especially acceptable

55. Huber, O.: Refraktionsänderung durch Trauma, Klin. Monatsbl. f. Augenh. **83**:523 (Oct.-Nov.) 1929; Refraktionsverminderung durch Trauma, ibid. **88**:230 (Feb.) 1932.

56. Collins, E. T.: The Sequelae of Hypotony, Tr. Ophth. Soc. U. Kingdom **37**:281, 1917.

57. Knapp, H.: Traumatischer Aufhebung der Vorderkammer, Myopie; Wiederstellung der Vorderkammer, acutes Glaucom, Heilung durch Eserin, Arch. f. Augenh. **12**:85, 1882.

in cases of traumatic myopia of short duration, such as those Bailey [6] and Damel [9] have reported, as well as in the cases of traumatic myopia of longer duration described by Sourdille,[15b] Morgan [15a] and others. The 2 cases reported hereafter are of a similar nature. Such a hypothesis, also admittedly speculative, not only conforms best with the clinical facts but has the scientific virtue of simplicity, since it offers one explanation for all the manifested phenomena in a given case. Furthermore, the coincidence of hypotony and myopia is not unusual in other ophthalmologic conditions. Both have been noted in iritis by Green [29] and Ladekarl,[58] among others. Many writers, including Hudelo [33] and Fuchs,[59] have discussed the attendant myopia in diabetes, and the hypotony of diabetic coma is well known to every ophthalmologist. The relation of hypotony to congenital myopia has been noted by Lagrange,[49] Urio [60] and many others.

REPORT OF CASES

CASE 1.—On Oct. 2, 1938 C. A., a 33 year old white man, was struck in the left eye during a fist fight. He received a laceration of the lower lid and noted an immediate loss of vision in the injured eye. He was treated by a physician and discharged as cured October 17 with instructions to get some glasses.

On this date the ocular examination gave the following results:

The vision was 20/20 in the right eye and 20/400 in the left. External examination of the eyes disclosed normal lids, conjunctivas and corneas. There was a healed laceration just under the left lower lid. The pupillary reflexes were normal in the right eye. The left pupil was semidilated and reacted sluggishly. This condition was attributed to the previous use of atropine. The left anterior chamber was shallow.

Slit lamp examination disclosed no abnormalities in the right eye. The left eye showed a mild flare and cells floating in the aqueous. The iris was intact and sluggishly active. The lens was clear but appeared more spherical than in the right eye, and there was a distinct separation between the anterior capsular band and the anterior band of disjunction (subcapsular band).

Ophthalmoscopic examination of the right eye disclosed clear media and a normal fundus. The media of the left eye were also clear. In the fundus it was noted that the whole perimacular area was edematous. There were several small flame-shaped hemorrhages grouped around and above the disk. Three choroidal tears were also seen above the macula, one directly above and one to the right and one to the left. They were arranged fanwise, concentric with the macula, but none reached the fovea.

The tension was 22 in the right eye and 7 in the left by the Schiøtz tonometer. A manifest refraction disclosed no refractive acceptance in the right eye. The vision

58. Ladekarl, P. M.: Hypotonische Iritis bei Amotio retinae, Acta ophth. **13**:301, 1935.

59. Fuchs, E.: Text-Book of Ophthalmology, ed. 5, Philadelphia, J. B. Lippincott Company, 1917.

60. Urio, H.: Die myopischen Fundusdegenerationen bei Anisometropie und ihre Bedeutung für die Theorien der Myopiegenese mit Bemerkungen zu der Tension des myopen und nichtmyopen Auges bei der Anisometropie, Arch. f. Ophth. **131**:377, 1933.

in the left eye was improved to 20/40 — 2 with a — 6.50 D. sphere. With atropine cycloplegia the vision was 20/20 with a — 0.25 D. cylinder, axis 180, in the right eye and 20/40 — 1 with a — 4.50 D. sphere in the left. The patient stated that his eyes had been examined in a hospital two years prior to the accident, at which time he had equal vision in the two eyes. Subsequent investigation confirmed this fact. The diagnosis made was traumatic iritis, myopia and hypotony with retinal hemorrhages and choroidal tears.

Perimetric field studies done on October 29 disclosed normal form fields in both eyes and a normal central field in the right eye. In the left eye there was a small irregular scotoma, roughly about five times the size of the blindspot, in the lower temporal quadrant. A central scotoma for 1 mm. red, blue and green objects

Comparative Tension and Refraction After Concussion *

Time Elapsed After Injury, Months	Case 1				Case 2			
	Right Eye; Uninjured		Left Eye; Injured		Right Eye; Uninjured		Left Eye; Injured	
	Tension	Refraction	Tension	Refraction	Tension	Refraction	Tension	Refraction
½	22	—0.25	7	—6.50				
1	17	—0.25	4	—4.00	17	+1.25	6	—4.25
2	17	—0.25	8	—3.25	22	+1.25	9	—3.50
3	15	—0.25	9	—3.50	19	+1.25	11	—3.50
4	15	—0.25	8	—5.00	22	+1.25	10	—3.50
5	15	—0.25	7	—4.00	22	+1.25	10	—2.50
6	15	—0.25	8	—4.50	22	+1.25	12	—2.50
7	19	—0.25	9	—4.50	22	+1.25	10	—2.50
8	17	—0.25	6	—4.50	22	+1.25	11	—2.75
9	15	—0.25	7	—3.75	22	+1.25	10	—2.75
10	17	—0.25	6	—4.00	25	+1.25	11	—2.50
11	17	—0.25	5	—4.50				
12	17	—0.25	6	—4.00	22	+1.25	10	—2.00
14	17	—0.25	6	—4.50				
16	17	—0.25	9	—4.00				
18	17	—0.25	12	—4.00				
20	17	—0.25	10	—2.50				
22	19	—0.25	13	—1.25				
24	19	—0.25	15	—0.37				
26	17	—0.25	17	—0.50				
28	25	—0.25	25	Emmetropia				
31	22	—0.25	22	+0.50				

* All tension readings were taken with the Schiøtz tonometer, and the values given are monthly averages. The refractive corrections given are also average monthly figures.

and a 3 mm. green object was also found. This disappeared subsequently, but the larger scotoma remained during the entire period of observation.

On November 2 the flare in the aqueous had disappeared and the eye was white and quiet. By November 14 the retinal hemorrhages were also absent and the fundus had lost its pale gray edematous appearance. Subsequently the choroidal tears became thin and pigmented. During the first three months the patient was seen frequently. He was treated with atropine and subconjunctival injections of hypertonic saline solution. Both were ineffective in raising the intraocular pressure, and both were discontinued. The refraction and the tension in both eyes were checked frequently, and with slight variations they remained about the same during this time. On discontinuance of the atropine the myopia increased as shown in the accompanying table. After several months the tension began to increase almost imperceptibly and the myopia slowly decreased. The two processes were irregular but definite and simultaneous. On December 30 the vision in the left eye had improved to 20/30—2, on February 6, 1939 it was 20/25—2 and on February 14 it was 20/20—3. The refractive corrections are given in the accompanying table.

At this time the anterior chamber was still shallow. The pupil, however, was normal in size and reaction when not under the influence of atropine. An accommodative weakness was noted, requiring a + 1.50 D. sphere to enable the patient to read Jaeger's test type 1 at 18 cm., as he could with the uncorrected right eye. This weakness disappeared in about three months. The shallowness of the anterior chamber continued unchanged for over a year and then also gradually disappeared. Subsequent details of tension and refraction are outlined in the accompanying table.

CASE 2.—C. P., a 31 year old white man, was struck in the left eye by a flying nail on Sept. 20, 1939. He was hospitalized until October 17. On October 23 the results of his ophthalmologic examination were as follows:

External examination of the right eye revealed no abnormalities. The left eye showed a clear cornea with a faint circumcorneal flush. The anterior chamber was shallow with the pupil dilated and sluggish.

The slit lamp examination of the right eye gave negative results. In the left eye there was a moderate flare, and red cells were seen floating in the aqueous. The anterior chamber was extremely shallow, and the lens seemed to be tilted slightly backward on the temporal side.

The ophthalmoscopic examination revealed clear media and a normal fundus in the right eye. In the left eye the lens was clear but the vitreous showed numerous small stringy and punctate opacities somewhat brownish in color, obviously the result of hemorrhage. The fundus appeared slightly hazy, but details could be seen adequately. The disk and the macula appeared uninjured. Completely surrounding the macula was a group of retinal tension lines arranged like the spokes of a wheel around a hub. There were two small choroidal tears above and temporal to the macula. Two disk diameters farther temporally there was a large patch of proliferative retinitis which extended peripherally and above as far as the fundus could be seen.

The tension with the Schiøtz tonometer was 17 in the right eye and 6 in the left. On cycloplegic refraction the vision in the right eye was 20/20 with a correction of + 0.75 D. sph. ⌒ + 0.50 D. cyl., axis 115. The vision in the left eye was 20/200 with a correction of — 2.25 D. sph. ⌒ — 2.00 D. cyl., axis 165. It was ascertained that the patient had had good vision in both eyes prior to the injury, with somewhat better vision in the left (injured) eye. The diagnosis was traumatic iritis, subluxation of the lens(?), hemorrhage into the vitreous, choroidal tears and proliferative retinitis of the left eye.

Perimetric studies done on October 28 gave normal results for the right eye. In the left eye the form field showed indentation of the whole nasal field up to the 25 degree isopter. Central fields taken with a 0.5 degree white object showed a nasal scotoma extending centrally to the 20 degree isopter with a finger-like projection below extending to almost 5 degrees below fixation. There was a relative central scotoma for blue and red with a 0.7 degree object. These findings remained unchanged during the period of observation.

The patient was treated with atropine and subconjunctival injections of hypertonic saline solution with no result. On November 28 the left eye was white and quiet with a clear aqueous. The vitreous still showed a number of small opacities. The retinal tension lines previously noted around the macula were fainter but still present. The vision in the left eye was 20/100 + 2 with a correction of — 2.00 D. sph. ⌒ — 1.50 D. cyl., axis 165. On Oct. 9, 1940, when the patient was last seen, the vision was 20/20 in the right eye and 20/70 — 2 in the left eye with a correction of — 0.50 D. sph. ⌒ — 1.50 D. cyl., axis 165. The macular

tension lines were gone, the choroidal tears had become pigmented and the patch of proliferative retinitis remained unchanged. As in the previous case, the tension and the refraction had gradually improved. Despite repeated attempts to trace this patient he was not seen again.

COMMENT

I believe that these 2 cases are best explained on the basis of a prolonged inhibition of the formation of aqueous as the result of trauma to the eye. Such an explanation seems to fit best the entire syndrome of acquired myopia and hypotony, shallow anterior chamber and normal pupillary size and reaction presented here. The temporary accommodative weakness noted in case 1 can be reasonably attributed in a markedly hypotonic eye to a slackening of the usually taut suspensory ligament and a forward displacement of the lens, as described by Collins.[56] This finding should not impair the validity of the offered hypothesis. On the other hand, if the clinical findings reported had been due to zonular injury—the only other tenable theory—of sufficient degree to cause such a prolonged myopia there would probably have been little or no accommodation left, little reaction to atropine and greater manifest abnormalities of pupillary size, shape and reaction. In addition there would still be the necessity of explaining the hypotony, presumably on the basis of impaired formation of aqueous.

A glance at the table will show that in both cases the tension and the refraction improved simultaneously. As the tension gradually increased the myopia decreased. There was also some evidence of the crossed hypotony in the uninjured eye, as described by Magitot.[10e] This was especially noticeable in case 1, in which the tension in the right (uninjured) eye averaged about 17 and gradually rose to 25 as the tension in the injured eye mounted.

Still another aspect of these cases is of general interest to ophthalmologists. Hypotony in an eye is an unwelcome development, universally regarded as potentially dangerous to vision. The dangers have been fully discussed by Lagrange,[49] Collins,[56] Kirby [61] and others. It is gratifying, therefore, to be able to report that in some cases, at least, a long-standing hypotony need not inevitably call for a hopeless prognosis. There are probably two explanations:

First, the standards of normal tension may be too high. At best they are vaguely defined and controversial. Most ophthalmologists estimate "normal" tension loosely to be somewhere between 15 and 25 mm. of mercury as commonly estimated with the Schiøtz tonometer or the equivalent obtained with other tonometers. Cridland [62] has defined

61. Kirby, D. B.: Ocular Hypotony, Am. J. Ophth. **23**:812 (July) 1940.
62. Cridland, B.: The Tonometer of Schiøtz, Brit. J. Ophth. **1**:352, 1917.

the normal limits as 12.3 and 26.1, with an average of 19.1. Magitot and Baillart [63] stated the belief that the upper and the lower limit are 28 and 15, respectively (Schiøtz), and Lagrange [49] said, "Ocular hypotony is that state of an eye in which the tension is fallen to 15 and less (Schiøtz)." More recently Magitot [10f] defined normal ocular tension as lying somewhere between 10 and 30 (Schiøtz).

A second possibility is that the generally accepted lower limit of normal tension may not be of as critical import in noninflammatory hypotony as it undoubtedly is in softening of an eye which harbors an inflammatory process. General ophthalmologic experience with inflammatory phthisis bulbi as opposed to cases such as those reported would seem to argue for such an interpretation. Hence, to coincide with clinical fact, normal tension could more properly be defined as that tension under which an eye exists and functions normally irrespective of its tonometric measurements.

All authors agree that there is no adequate form of therapy for traumatic myopia. My experience confirms this opinion. Symptomatic treatment is used whenever indicated. Miotics are employed when there is an attendant rise in tension. In the more frequent cases of myopia with hypotony and signs of uveal involvement atropine and the other usual remedies are employed. The *colmatage* suggested by Lagrange [49] and others for hypotony does not seem to be justified unless it is certain that the cause is increase in the excretory channels and not something else. As in so many other ocular lesions, time and the patient's inherent constitutional reaction to traumatic insult are of great assistance. At least, this seems to be true with young, vigorous, healthy persons, such as those whose cases I have reported.

In both these cases a poor prognosis was given early. The subsequent recovery, especially that in the first case, was as embarrassingly unexpected as it was gratifying. While the vision of the injured eye in the second case was not as good as that in the first, the poorer vision was attributed to the retinal lesions and not to the myopia or the hypotony. The clinical course was practically identical in the 2 cases, and the final result might have been equally good in the second case had it not been for the pathologic change in the posterior segment. In all such cases, therefore, judgment should be reserved unless there is visible and unequivocally permanent damage. The prognosis may be better than would at first appear.

63. Magitot, A., and Baillart, P.: Modification de la tension oculaire sous l'influence de pressions exercées sur le globe (recherches expérimentales), Ann. d'ocul. **156**:656, 1919.

It is of interest to note that multiple choroidal ruptures around the macular region may cause little final impairment of vision, as shown by case 1. This fact has also been pointed out by Neame.[64]

SUMMARY

Traumatic myopia is usually the result of concussion or indirect trauma, and hypotony is a frequent accompaniment. In the majority of cases it is transient and disappears within three or four weeks, often sooner, though it may persist for several years. In rare cases it is permanent.

In the cases of myopia of short duration ciliary spasm initiated by trauma is the most common cause. In cases of myopia of longer duration zonular relaxation or injury is an etiologic factor.

It is suggested that another important cause is interruption of the formation of aqueous with anterior displacement of the lens.

Permanent traumatic myopia is due to anterior dislocation or subluxation of the lens or to elongation of the eyeball as the result of inflammatory processes usually in the posterior segment.

Traumatic hypotony is rarely due to scleral rupture. The most probable cause is interruption of the secretion of aqueous.

Both traumatic myopia and traumatic hypotony may exist for several years without permanent impairment of vision.

The prognosis should be guarded, but even in cases of myopia of several years' duration the ultimate result may be good.

No treatment is of avail.

Two cases of traumatic myopia with hypotony and choroidal tears are reported. In one there was complete visual and functional recovery after twenty-eight months. In the other there was partial recovery within twelve months, after which the patient was lost from sight.

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64. Neame, H.: Multiple Ruptures of Choroid with Retention of Good Vision, Brit. J. Ophth. **24**:399 (Aug.) 1940.

PROCESS OF LEARNING SIMULTANEOUS BINOCULAR VISION

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Binocular vision comprises three principal processes, namely (1) the coordination of the extraocular muscles and the intrinsic adjustment of the ciliary and other internal muscle fibers in order to bring the two images on the fovea, (2) the fusion of the two monocular images or sensations into a single perception and (3) the projection of this composite image into space.

Fusion is an association of the images received by the two retinas so that one composite picture is formed. Exactly how this takes place is still a controversial subject. Some investigators believe that the process is a diffuse cortical one, while others assume that a fusion center exists in the cortex although its anatomic location has not been found. According to the latter view the fusion center would receive fibers from the occipital cortex of both sides and also proprioceptive fibers from the extraocular muscles. The images must be fused not only for single vision but for a "true impression of depth."

In order that fusion may take place effectively, an impression of the object seen must fall on the fovea of each eye and the extraocular and the intrinsic muscles must maintain the proper tension and tonicity in order to focus the images on the foveas so that the object may be recorded by the brain as one. This process of binocular vision consists in uniting two monocular images into a composite perception of a single perception. It requires a high integration of extraocular and intrinsic muscle activity, and its existence is frequently accepted without its development's ever being criticized.

Is binocular vision with fusion a process with which human beings are endowed at birth and which functions more or less efficiently immediately or soon after birth, or is it an ability which has to be developed and learned during the early part of life? In other words, are fusion and binocular vision learned in the same way as walking, talking, swimming or speaking, or do they form an activity which is fully developed soon after birth?

On reading the literature on ophthalmology one gathers the impression that there exists some sort of a fusion faculty which is present at

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birth or which at any rate maturates into full activity during the first few months of life. Whether or not one would have binocular vision would depend on the existence of a defectless fusion faculty. For example, Worth [1] considered a lack of, or a defective, fusion faculty the principal factor in causing squint. In the early days some authors even believed that once binocular vision was lost it could never be restored, and even today there are some who think that in "essential alternating squint" there is absence of a fusion faculty and the patient therefore cannot learn to see binocularly. Such a concept of a fusion faculty would require the assumption of a specific fusion center. However, as was pointed out in a previous paper,[2] the concept of a fusion center has little factually demonstrable basis. It would, therefore, be much more according to fact and in agreement with present day psychologic opinion to consider binocular vision not the result of a fusion faculty but the result of a diffuse and complex cortical activity. According to this point of view binocular vision, fusion and stereopsis should be considered complex cortical processes which are gradually learned throughout the first few years of life; these processes may be changed or perfected throughout the greater part of life, or, at any rate, some changes may be effected, as long as one may assume a person capable of learning.

According to Gesell,[3] the child first fixates and visually pursues a moving object or light at the age of 5 to 6 months. Gradually his ability improves, but not until the average child is 20 to 24 months old does he definitely regard and visually examine or pursue a small moving object, such as a pellet or a moving string.

Binocular vision with fusion depends on the ocular coordination of the two eyes. For one to see clearly and singly the images must fall on the two foveas, and for this to take place the two eyes must work in coordination. Since at birth or shortly after there is little coordination of the two eyes and thus little simultaneous binocular vision, the child must learn how to use his eyes together, and it may be assumed that the process of learning to see binocularly differs little from any other learning process. At first the child exercises his muscles by trial and error, and the result of his random movements is clear vision. Gradually he learns to repeat the movements which at first more or less accidentally bring clear and single vision. Eventually he learns to associate a certain muscular pattern with clear and single vision and integrates his eyes

1. Worth, C. A.: Squint: Its Causes, Pathology and Treatment, ed. 5, London, Baillière, Tindall & Cox, 1921.

2. Burri, C.: The Concept of Abnormal Retinal Correspondence, Arch. Ophth. **19**:409-424 (March) 1938.

3. Gesell, A.: The Mental Growth of the Pre-School Child: A Psychological Outline of Normal Development from Birth to the Sixth Year, Including a System of Developmental Diagnosis, New York, The Macmillan Company, 1925.

accordingly. Through the process of repeated reciprocal innervation and inhibition of the tonus in the opposing muscles the organism produces a tendency of the images to fall on the two foveas, and through constant repetition the child learns to fuse the separate images.

But before a child has fusion he builds up the "accommodative convergence" association. This occurs through association of movements of convergence and the innervation of the ciliary muscles, which are purely proprioceptive processes. At this stage the child's visual behavior is mainly a proprioceptive space direction affair, with poor coordination, resulting either in overconvergence or in overinnervation of his ciliary muscles. It causes diplopia and blurred vision, which gradually the child recognizes from his association with touch. He discovers that when his eyes tell him there are two objects his hands tell him there is only one. This stage is probably reached at the age when more accurate and clearer vision is needed. Now, a higher integration is developed. Through voluntary attention he learns to control indirectly his internal rectus muscles and his ciliary muscles, because of their associated function with convergence. Thus, by means of voluntary direction of attention he adjusts his eyes until clear vision is obtained and until he has fusion. The fusion becomes his interpretation or perception of a specific image and response pattern of his visual apparatus. This process seems to take place regardless of the exact position of the two eyes or the relationship of the two retinas. The main requirement seems to be that the two images fall on the two foveas. In order to achieve this goal considerable adjustment of the neuromuscular mechanism must constantly take place, and such plasticity in relationship seems to occur regardless of, or in addition to, any apparent exact relationship between the two eyes. That the two eyes sometimes function together efficiently in spite of an existing abnormality in their neuromotor relationship becomes evident from the fact that many persons have had considerable muscular imbalance for a long period, even throughout life, without having any symptoms at all. The eyes evidently may possess considerable compensatory function. That this is the case has been shown both by Park [4] and Peckham,[5] who independently and by different means arrived at the same conclusion, namely that the two eyes are frequently capable of working effectively as a unit even though their physiologic relationship or correspondence may not be exact.

At present little factual material which shows the development of binocular vision during infancy is on hand. Although it is commonly

4. Park, G. E.: An Investigation of the Angular Relation of the Visual (Visierlinie) and Optic (Corneal) Axis, Am. J. Ophth. **19**:967-974, 1936.

5. Peckham, R. H.: Foveal Projection During Ductions, Arch. Ophth. **12**: 562-566 (Oct.) 1934.

known that during the first year of life a baby's eyes show little coordination and accordingly little simultaneous binocular vision, not much is known of how and when full binocular vision and fusion and stereopsis are developed. Ida Mann [6] found that stereopsis could be observed at about the age of 6. Lancaster [7] reported that the visual acuity of young children is lower than that of adults, and, in a recent paper on developments in orthoptics in connection with reading problems, Nugent and Ilg [8] reported that the 5 and the 6 year old children whom they tested failed to have fusion at the near point and had no stereopsis. This observation agrees with the findings in an unpublished study on reading difficulties which Park and I carried out on 250 school children in the first eight grades. In this study we found that a great many of the first graders had poor vision even though they had little or no refractive error, and poor fusion and little stereopsis were found. These findings were particularly apparent at the near point. They indicate that the problem is concerned with a lack of maturation or a low achievement in the development of good binocular vision and not with visual defects.

Of course the acquisition of simultaneous binocular vision usually takes place without much formal training under normal conditions. The learning process occurs naturally in the same manner as learning to walk or to talk. But if abnormal physiologic or anatomic conditions exist, such as an uncorrected refractive error, or if, in addition, the child is forced to do much near work before normal binocular integration is developed, the natural development, or the learning, of simultaneous binocular vision may be inhibited, phorias or even squint may occur and in some cases proper control of binocular vision may never be acquired. Early formal training should then be employed.

Since observation of the development of young infants indicates that fusion and binocular vision are learned processes, the problem remains to discover how they are acquired. Can it be assumed that the learning of binocular vision follows the same fundamental laws as does any other motor or mental activity, and will it be possible to control experimentally and demonstrate this process?

In order to obtain the truest picture of how fusion is learned one should naturally study a person who never had any practice in the process of binocular vision, i. e. either a small baby or else a person who after having been blind in one or both eyes from birth has through an operation regained his sight and then learned to see binocularly. Either of

6. Mann, I. C.: Convergence Deficiency, Brit. J. Ophth. **24**:373, 1940.

7. Lancaster, W. B.: Fifty Years' Experience with Ocular Motility, Am. J. Ophth. **24**:741-748, 1941.

8. Nugent, O. G., and Ilg, V.: Newer Developments in Orthoptics, with Reference to Reading Problems, Arch. Phys. Therapy **22**:225-232. 1941.

these types would be difficult to secure for study. However, another type of subject, although less ideal, might be used. It seems possible to throw some light on the problem from the results of fusion training and the training in binocular vision of people with concomitant strabismus.

Teaching fusion to a patient who has any kind of a squint means essentially training him to see an image with each eye and to coordinate his eyes in such a way that the two images fall on the foveas while he holds the visual axes parallel and to make him simultaneously accept these foveal images. This process must consist of muscular integration and coordination of the two eyes and of voluntary direction of the attention and of the will toward fusion. Unless there exists some direct muscular anomaly, by developing fusion and stereopsis a patient may gradually learn to hold his eyes straight. This process of learning binocular vision is slow and tedious. However, the gradual development can be experimentally studied and demonstrated. It is the purpose of this paper to demonstrate objectively the learning of fusion and binocular vision in the gradual development of parallelism of the visual axes.

The subjects who participated were patients who obtained fusion training in order to establish parallelism of their visual axes and thus to correct either divergent or convergent squint and obtain binocular vision and fusion. Some of the patients received only fusion training, while with others the training followed an operation on muscles.

Six subjects with different types of squint were used. They received weekly orthoptic exercises and practiced fusion and stereopsis in any way seemingly advisable for their specific need. Once a month a check-up test on the synoptophore was given, and the average measurement of four trials at fusion was used as the criterion of achievement. Each measure was in terms of the number of degrees from zero on the scale of the synoptophore. This measure indicates the degree of deviation from parallelism. Each monthly average score of the four trials was used in constructing the learning curves.

The 6 patients were chosen because they represented different initial conditions. The first had esotropia of the accommodative type, the second alternating esotropia and the third esotropia with amblyopia in one eye. These three persons recovered with orthoptic exercises alone and at the end of the training period had good binocular vision with and without glasses. Their learning curves are shown in charts 1, 2 and 3. Chart 4 shows the learning curve of a patient who learned fusion after an operation had been performed, and chart 5 shows the learning curve of a patient with postoperative divergent squint. Chart 6 shows the learning curve of a patient with alternating divergent squint

who did not improve. These patients received exercises for eighteen to twenty-four months. The training was carried out with the refractive errors corrected if necessary, and the fusion training of the first 3 patients was supplemented with wearing of bifocals and use of atropine sulfate.

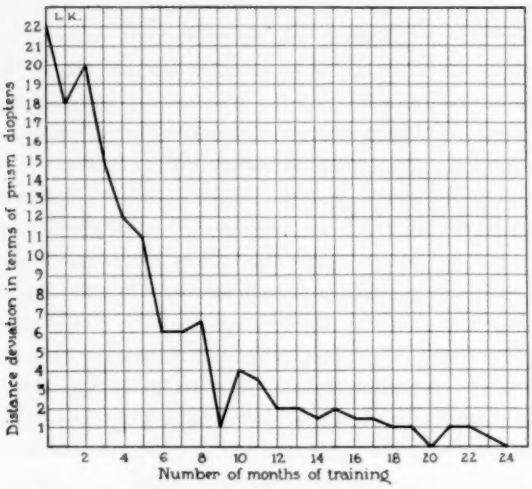

Chart 1.—Learning curve of a patient with esotropia of the accommodative type who recovered with exercise alone.

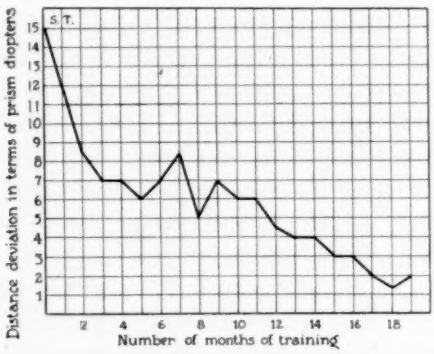

Chart 2.—Learning curve of a patient with alternating esotropia who recovered with exercise alone.

Since in this study I was primarily interested in showing that the learning of binocular vision follows the same fundamental laws as any other type of learning and thus gives the same type of learning curve, it is not necessary to review in detail the initial and the end condition of each subject. I shall describe these for only 2, in order to show the type of patient used.

Chart 2 represents the learning curve of a 6 year old boy who had a left esotropia of 18 prism diopters for near and of 10 prism diopters for distance vision with glasses; without glasses the deviation was 22 prism diopters for near and 15 for distance vision. The left eye was amblyopic and had a corrected visual acuity of 20/65, while the vision of the right eye was 20/25. After completion of the training the corrected vision was 20/30 in the left and 20/15 in the right eye. There remained an esophoria of 4 prism diopters for near and of 2 prism diopters for distance

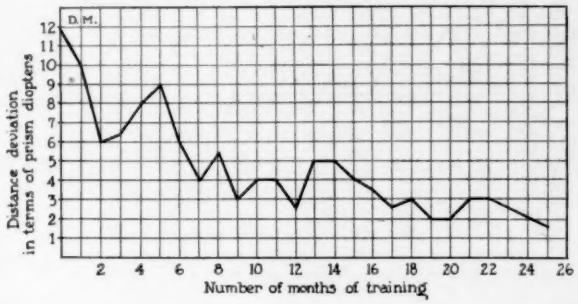

Chart 3.—Learning curve of a patient with amblyopia who recovered with exercise alone.

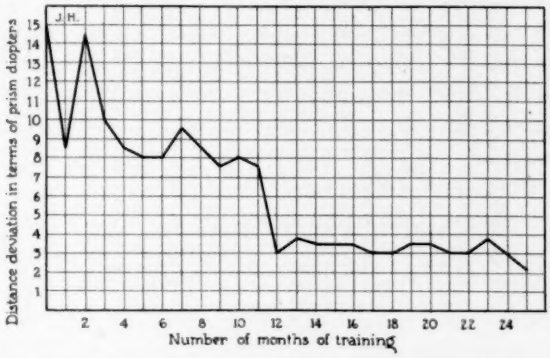

Chart 4.—Learning curve taken during postoperative training of a patient with esotropia.

vision. The eyes were parallel with and without glasses, and the boy had good fusion and good stereopsis. His abduction was 12 prism diopters base in and his adduction 22 prism diopters base out. Except patient 6, the other patients had similar end results. However, patient 6 had alternating divergent squint varying from 15 to 25 prism diopters and absolutely no simultaneous binocular vision before training. His strabismus was still about the same in amount after seventeen months of training, and he had little binocular vision at the point of his deviation.

One reason for his lack of improvement may have been his poor cooperation in doing the exercises. However, there are probably other factors influencing such an absence of progress, perhaps muscular anomalies or other causes the nature of which is still unknown. It may be stated only that there was no refractive error and the retinal correspondence was normal. Since the etiology of squint is not the subject of this paper, further discussion of this problem need not be made.

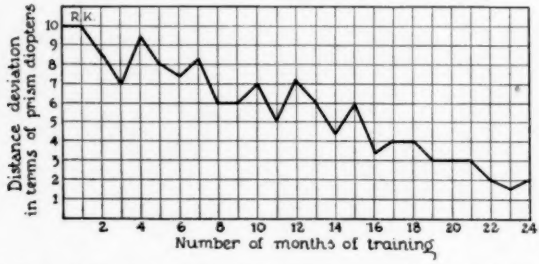

Chart 5.—Learning curve taken during postoperative training of a patient with divergent squint.

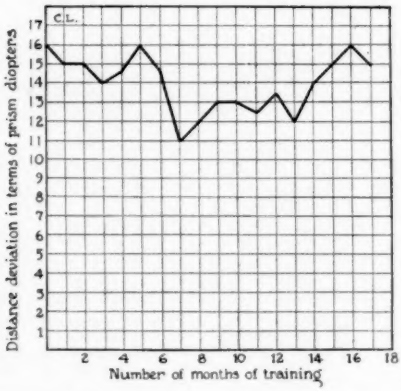

Chart 6.—Learning curve of a patient with alternating divergent squint who did not improve.

Five of the curves are typical learning curves. Their shape is much the same as that of learning curves obtained from plotting the progress of any motor or mental activity. In other words, the process of learning binocular vision and fusion and stereopsis follows the same laws as any other kind of learning, and this is the case even though the acquisition of simultaneous binocular vision is not directly and voluntarily controllable, as is the acquisition of some of the other activities, such as learning to walk, to swim or to speak a new language. The fact that the laws of learning apply in spite of this apparent difference in voluntary

control between the visual functions and other, more voluntary activities indicates that the complex neuromotor integration in the various functions which make up simultaneous binocular vision are cortical in nature and consist of a higher and more complex neural integration than is frequently assumed. If this is true the same methods may be used in the teaching of binocular vision as are used in the teaching of a new language, swimming or any other process which a person may have to learn. The significance of this fact becomes at once apparent. If developing binocular vision is learning and is not dependent on some mysterious faculty which a person either possesses or, as frequently happens, does not possess, then the treatment of squint and other muscular and fusional anomalies may come under a type of control the laws of which are scientifically understood and governable. But these findings have still other significance. If the development of binocular vision in the correction of squint is learning, then it may be assumed that the process of learning, or developing, binocular vision during the first part of life follows the normal laws of learning. If this is so the development of binocular vision may be better understood, and at the same time normal development may be guided and controlled. Lancaster [7] discussed the importance of early development in a recent article on ocular motility. He applied the theory of conditioned reflexes to the development of various visual processes and showed how by means of conditioning and reenforcement the complex visiomotor activities develop out of a series of unconditioned reflexes. He emphasized that the development of visual acuity, accommodation, fixation, convergence and fusion can be explained in terms of conditioning of reflexes and that when these functions fail to develop, thus causing amblyopia to persist or to develop from lack of use or causing squint or other visiomotor anomalies, attention must be given to the conditioning of reflexes.

Conditioned reflexes are acquired by usage, and they become established and fixed by repetition or exercise. Thus the major factor in developing correct visual habits is proper conditioning, and according to Pavlov conditioning takes place in conformity with definite laws and these laws are laws of learning. The findings of this study strongly substantiate Lancaster's point of view. Binocular vision as well as binocular abnormalities must accordingly be considered as a dynamic integration and cannot be treated merely as the product of overacting or underacting muscles.

Accordingly, if the process of binocular vision is developed gradually, or, in other words, if it is learned during the first few months or years of life, then it may be assumed that there is great individual variation in the ability to learn fusion and stereopsis owing to various maturational or intellectual factors as well as various eventual structural or functional

abnormalities. These various factors may affect the oculomotor or neurofusional mechanism either directly or through a general effect on the organism as a whole. Anything which would inhibit or retard the process of learning fusion and stereopsis may inhibit binocular vision in general. The effects of the retardation or inhibition may become an important factor in the development of squint and also of reading difficulties. For example, a child when he should learn to read may not be ready to do so merely because his binocular mechanism is not sufficiently integrated and developed. Pushing the learning of reading may then well prevent him from normal reading progress and cause him serious reading disabilities or even turn him into a nonreader or at least into a poor and slow reader. An understanding of the early development of binocular vision will provide the means to control and guide the learning process, and thus it may furnish an aid in preventing reading difficulties and in correcting abnormal visual functions. According to the findings of this study the development of simultaneous binocular vision is a learning process and should be guided and taught as is any other physical and mental activity which a person may wish to learn. Thus teaching simultaneous binocular vision should follow good teaching methods and the principles of the laws of learning.

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SUPERFICIAL PUNCTATE KERATITIS IN MILIAN'S ERYTHEMA OF THE NINTH DAY

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Milian in 1917 [1] and again in 1920 [2] described an erythema of the body appearing between the seventh and the twelfth day after arsenical therapy and designated this occurrence "erythema of the ninth day." As a clinical entity this early erythematous reaction is becoming firmly established by its characterization as a relatively short, acute illness in which fever with or without chill, a self-limited rash, tonsillitis, pharyngitis and cervical adenitis are noted on the seventh to the twelfth day after injections of trivalent arsenic compounds.

Ocular complications of arsenical therapy have been frequently reported, including acute inflammatory reactions involving any or all of the ocular tissues. However, except for the case report of Thomas and Cañizares,[3] the literature contains practically no references to these ocular disorders as part of ninth day erythema, although it is probable that some have occurred from the seventh to the twelfth day. That corneal complications are relatively rare is surmised, as but 4 instances have been noted in the large syphilis service of Bellevue Hospital since 1936 and none are on record in the ophthalmic service. Curiously, all 4 of these cases appeared within a period of one year and in 3 the corneal complications were associated with an acute arsenical erythema, so-called Milian's erythema of the ninth day.

There is no common opinion regarding the nature of the phenomena of this arsenical erythema. As early as 1911 scarlatiniform or morbilliform eruptions from arsenical chemotherapy were reported.[4] Stuhmer [5]

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1. Milian, G.: Arsénobenzol, érythèmes et rubéole, Paris méd. **2**:131 (Aug. 11) 1917.

2. Milian, G.: Les érythèmes arsénicaux du neuvième jour, Rev. de méd. **37**: 222 (April) 1920.

3. Thomas, E. W., and Cañizares, O.: Relapsing Early Acute Arsenical Erythema, Arch. Dermat. & Syph. **42**:30 (July) 1940.

4. Ravaut, P.: Sur un type spécial d'accidents nerveux et cutanés survenant brusquement de trois à cinq jours après la seconde injection de "606"; leur rapport avec l'anaphylaxie, Bull. et mém. Soc. méd. d. hôp. de Paris **32**:365

(Footnotes continued on next page)

apparently was the first to correlate such erythema with the time interval and suggested individual hypersensitivity as the causal factor.

Milian described two distinct types of reaction: firstly, an early arsenical erythema simulating measles or scarlet fever, and, secondly, a severe vesiculoedematous and exfoliative dermatitis. In his later publication he elaborated a biotropic theory suggesting the ability of certain drugs to activate latent micro-organisms. In this sense he explained "ninth day erythema" as abortive measles or scarlet fever. These assumptions were refuted by both American and European schools of thought.[6] Actually the cases he reported showed little clinical support for a diagnosis of measles, rubella or scarlet fever. On the other hand, certain features suggested an acute infectious process and also reactions of fever and eruptions more or less characteristic of heavy metal poisoning following chemotherapy with gold and bismuth.

An allergic basis for ninth day erythema has been claimed[6a] because of positive Prausnitz-Küstner and intradermal reactions, but the claim has been weakened by equivocal or negative findings.[7] In fact, Milian and Garnier used the intradermal test to differentiate early erythema from arsenical dermatitis of the exfoliative type, although this test has been deprecated owing to the danger of precipitating exfoliative dermatitis or sensitization to arsenic.[8] A toxic basis for the erythema has been advanced [9] because of the inability of the hepatic, the renal and

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(Nov.) 1911. Brauer, A.: Zur Kenntnis der Salvarsandermatosen, Dermat. Ztschr. **19**:800, 1912. Nicolas, J., and Moutot, H.: Trois ans d'arsénothérapie aux syphilitiques, Ann. de dermat. et syph. **5**:391, 1914. Neisser, A.: Ueber die Verwechslung von Quecksilber- und Salvarsanexanthemen, München. med. Wchnschr. **62**:122, 1916.

5. Stuhmer, A.: Ueber Salvarsan, München. med. Wchnschr. **58**:2447, 1912.

6. (*a*) Schreiner, K.: Ueber Milian's "Erytheme des 9. Tages," Arch. f. Dermat. u. Syph. **167**:94, 1932. (*b*) Tzanck, A.: Érythèmes morbilliformes et rougeole, Bull. Soc. franç. de dermat. et syph. **43**:379 (Feb.) 1936. (*c*) Gordon, H.: Erythema of the Ninth Day (Milian), Brit. J. Dermat. **48**:281 (June) 1936. (*d*) Keim, H. L.: Erythema of the Ninth Day, Arch. Dermat. & Syph. **31**:291 (March) 1935.

7. Wainstein, A., and Smelov, N.: Sur la question de la symptomatologie, de la pathogénie et de la thérapeutique des exanthèmes précoces arsénobenzoliques "érythèmes du neuvième jour" de Milian, Ann. de dermat. et syph. **8**:215 (March) 1937. Garnier, G.: Les érythèmes des arsénobenzols, Thesis, Paris, Jouve & Cie, 1929.

8. Cannon, A. B., and Karelitz, M. B.: Intradermal Tests in Relation to Arsphenamine Dermatitis, Arch. Dermat. & Syph. **29**:485 (April) 1934. Stokes, J. H.: Modern Clinical Syphilology, ed. 2, Philadelphia, W. B. Saunders Company, 1934, p. 485.

9. Keim, H. L.: Erythema of Ninth Day, Arch. Dermat. & Syph. **31**:291 (March) 1935.

other systems to detoxify completely the breakdown products of the arsenical drugs, but this thesis has received no laboratory confirmation. The hypothesis that the initial injection of drug imbalances the autonomic nervous system [10] also remains unconfirmed.

The entity ninth day erythema appears in practically all cases reported in the five day interval following seven days after the first injection of a trivalent arsenical and usually after two or three injections have been given. In the cases reported by Cañizares and Thomas [11] the appearance of constitutional symptoms after the seven day incubation period apparently was uninfluenced by the number or the time of the injections given in the intervening period. Gougerot and Brouet [12] have reported the only case so far of eruption and fever occurring but two days after the first and only injection. Cañizares and Thomas [11] have reported 2 cases in which one or more relapses occurred and stated the belief that therapy can well be tolerated and need not be discontinued, as the intensity of the reactions decreases with the number of injections given, but they offered no explanation for the increasing ability of the patient to tolerate the drug.

Of the 4 cases here described, 1 has previously been reported.[3] In 3 cases of syphilis, 1 in the primary and 2 in the secondary stage, and in 1 case of "trench mouth" the patient was treated with arsenical drugs. In all 4 patch tests gave negative results.[13] In 2 cases the ocular complaints occurred five to seven days after but one injection. The ocular symptoms appeared in 1 of the other 2 cases nine days after the second of two erythematous reactions and in the other fourteen days after the first injection of a second series.

The immediate complaints consisted of "smoky" or blurred vision accompanied by redness of the eyes, photophobia, lacrimation and a

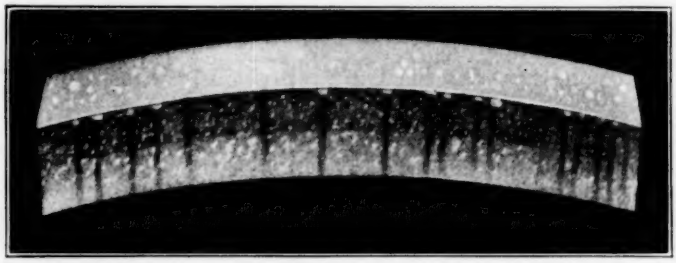
10. Gjessing, H. C.: A Form of Salvarsan Dermatitis (Ninth Day Erythema), Acta dermat.-venereol. **9**:185 (Oct.) 1928. Mueller, cited by Gjessing.

11. Cañizares, O., and Thomas, E. W.: Early Acute Arsenical Erythemas, Arch. Dermat. & Syph. **39**:867 (May) 1939.

12. Gougerot, H., and Brouet, A.: Érythème biotropique du deuxième jour au cours d'un traitement par le 914, Ann. d. mal. vén. **30**:850 (Nov.) 1935.

13. It is puzzling that all 4 of our cases occurred within a relatively short period, and we have never seen punctate keratitis due to arsenical drugs before or since. The reaction cannot be attributed to the particular drug used, because no 2 patients were treated with the same batch of drug and the reaction occurred after mapharsen as well as after arsphenamine and neoarsphenamine. The distilled water cannot be blamed, because in 1 instance the drug was dissolved in water obtained from 10 cc. ampules prepared by a large drug firm, while in the other cases different batches of distilled water prepared at Bellevue Hospital were used. In the latter instances large amounts of drugs were prepared at one time for the treatment of many patients, only 1 of whom in each instance had an acute arsenical erythema type of reaction.

mild sensation of sandiness or of a foreign body. These symptoms either followed the height of erythema or occurred as the erythema faded and desquamated. The acute phase lasted from two to four weeks, the last symptoms to disappear being the photophobia. In detail, the palpebral and bulbar vessels were dilated, giving redness to the tissues, and there was a scant mucoid discharge. The entire area of corneal epithelium had a diffusely scattered superficial finely punctate graying without any great tendency to cellular desquamation or erosion, the remaining corneal layers revealing no reaction; staining with fluorescein most often showed no breakdown. Slit lamp observation confirmed this picture and suggested that the individual lesions were edematous cells rather than erosions. This punctate keratitis tended to crop formation at five to six day intervals, the new lesions appearing before resolution or disappearance of the old and affecting mainly the central corneal area. In all cases the corneal involvement was self limited, being



Superficial punctate keratitis in ninth day erythema.

uninfluenced in evolution by therapy but made tolerable by palliative treatment.

Duke-Elder [14] summed up the toxic process in the eyes due to arsenic as described by a number of authors as a toxic conjunctival hyperemia with pericorneal injection occurring in hypersensitive persons and appearing clinically as an (exudative) exfoliative dermatitis (multiform) in association with (*a*) secondary infection, (*b*) bullae followed by croupous conjunctivitis and resembling pemphigus, (*c*) exfoliative keratitis with denudation of large areas, (*d*) degenerative interstitial keratitis, (*e*) acute corneal necrosis and (*f*) corneal desensitivity as a manifestation of angioneurotic edema plus toxicity. These lesions are common to reactions produced by other agents, as is evident from the description of keratoconjunctivitis and a superficial punctate keratitis

14. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1938, vol. 2, p. 1711.

due to chrysarobin (chrysophanic acid) as reported by Igersheimer,[15] Cohen [16] and Rychener.[17]

However, in none of the reports noted have the ocular complaints or the mild superficial punctate keratitis been described as a possible part of the symptom complex of Milian's ninth day erythema. It is possible, however, that in some cases superficial punctate keratitis has been attributed to the syphilis rather than to the drug, as the records of Bryn [18] described a deeper type of punctate keratitis without reference to time of occurrence during treatment with bismuth.

REPORT OF CASES

CASE 1.—(This case has previously been reported [3] and is added herewith by permission of the authors.) C. F., a married Negro woman aged 22, had secondary syphilis with a Wassermann reaction of 4 plus. Feb. 25, 1939, 0.04 Gm. of mapharsen was administered. February 27, March 1 and March 3, 0.06 Gm. was administered. March 3, in the evening, the patient had a chill, nausea and vomiting, followed by a temperature of 103.8 F. March 4 there were generalized erythema, injection of the conjunctivas, photophobia, lacrimation, superficial punctate keratitis and tenderness of several cervical nodes. The fever lasted five days and the erythema four days. March 13, 0.04 Gm. of mapharsen was administered, and there was a recurrence within a few hours of the symptom complex, with addition of strawberry tongue. Subsidence began in two days and was complete in four days. March 21, 0.02 Gm. of mapharsen was administered, with recurrence within a few hours of the constitutional symptoms, which reached their height within twenty-four hours. Subsidence of the symptoms began in two days; the superficial punctate keratitis persisted for ten days. April 5, 0.02 Gm. of mapharsen was administered; the temperature was 102.4 F. same evening. No eruption occurred, but keratitis recurred, lasting five days. April 13 and 22, 0.02 Gm. of mapharsen with 0.3 cc. of epinephrine hydrochloride in 1:1,000 dilution was administered; there were slight and brief rises in temperature on both occasions but no constitutional reactions, although keratitis was present for several days after each injection. April 25, 0.3 Gm. of acetylglucoarsphenamine was administered, with no reaction. Eight injections of bismuth subsalicylate followed. Mapharsen was again given, in doses of 0.01 Gm., without difficulties. The dose was finally increased to 0.06 Gm. without reactions.

CASE 2.—C. S., a married white woman aged 42 with Vincent's infection, eight days after her first injection of arsphenamine and the first day after her second injection had malaise, a temperature of 100.5 F. and a fine rash. As the rash faded (on the twelfth day) the eyes became red, photophobic and sandy; superficial punctate keratitis was present. The duration of the acute ocular complaints was five days and the duration of the keratitis sixteen days.

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15. Igersheimer, J.: Ueber Schädigung der Augen durch Chrysarobin, Klin. Monatsbl. f. Augenh. **50**:518, 1912.

16. Cohen, P.: Der Chrysarobinkeratitis, Wchnschr. f. Therap. u. Hyg. d. Auges **15**:353, 1912.

17. Rychener, R. O.: Case Report, Am. J. Ophth. **13**:1096, 1930.

18. Bryn, A.: Ein Beitrag zur Kenntnis der Keratitis punctata syphilitica, Klin. Monatsbl. f. Augenh. (supp.) **78**:89 (June) 1927.

CASE 3.—C. S., a married Negro woman aged 30, had secondary syphilis with a Wassermann reaction of 4 plus. The third day after the initial treatment (with neoarsphenamine) there were prostration, swelling of the back and the legs, generalized erythema, chills and fever, nausea and vomiting and epigastric distress. The direct van den Bergh reaction was moderate; indirect, 1 plus. The reaction for albumin in the urine was 2 plus. The fifth day after the injection the patient had a veil over the eyes; this lasted two days. The conjunctivas were injected, and there was superficial punctate keratitis. The duration of the ocular distress was twelve days. May 8, 1939 one injection of neoarsphenamine (0.1 Gm.) was given.

CASE 4.—C. V., an unmarried Negro aged 21, had primary syphilis with a Wassermann reaction of 4 plus. A patch test gave negative results. Ten days after 0.1 Gm. of mapharsen was administered there occurred constitutional symptoms comprising the characteristic Milian erythema syndrome. Arsenical therapy was continued, with a reaction on the fourteenth day after the initiation of treatment and again on the twenty-third day, when superficial punctate keratitis appeared. There was a constitutional reaction on the thirty-ninth day of treatment but no recurrence or aggravation of the keratitis. A Wassermann test gave negative results on the forty-fifth day of treatment. Mapharsen was used throughout: May 2, 1939, 0.1 Gm.; May 3, 0.06 Gm.; May 5, 8, 10, 12, 15 and 24, and June 7, 12 and 14, 0.06 Gm.

SUMMARY

Three new cases are reported in which a mild, self-limited superficial punctate keratitis occurred in association with fever and a generalized erythema as part of the clinical entity known as Milian's ninth day erythema. The syndrome followed trivalent arsenical therapy of 2 syphilitic and 1 nonsyphilitic patients.

No complicating visual loss or organic sequelae occurred in this series.

39 East Seventy-Fifth Street.

CONJUNCTIVAL MYIASIS DUE TO OESTRUS OVIS

REPORT OF A CASE

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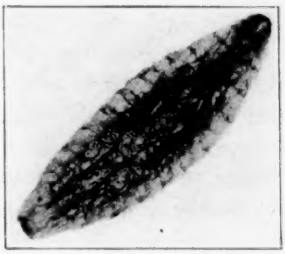
AND
M. K. HUMPHRIES JR., M.D.
CHARLOTTESVILLE, VA.

The American literature does not contain many references to conjunctival infestation with larvae of the sheep gadfly. There are a fairly large number of reported cases in foreign publications. Serious consequences are apparently infrequent, and this is likely one reason no more cases are reported. A number of articles dealing with intraocular myiasis can be found. DeBoe [1] in 1933 reported seeing a larva



Larva of Oestrus ovis (× 50).

coming through the lamina cribrosa. Other authors who have reported cases of intraocular myiasis are O'Brien and Allen,[2] McBride [3] and Wright.[4] Sniderman [5] in 1939 reported a case of conjunctival myiasis and in reviewing the American literature could find only 5 previously reported cases. These were by Stark,[6] Lyon,[7] Schenck,[8] Bedsole and Neal [9] and Mustard.[10]

REPORT OF CASE

While working at his job with the Virginia Public Service Company, the patient was struck in the right eye by a fly. No immediate discomfort was noticed. Two hours afterward he felt as if there was something alive and crawling about in the conjunctival sac. There were itching and greatly increased lacrimation. He immediately sought medical advice, and examination revealed the cul-de-sac to be

1. deBoe, M. P.: Dipterous Larva Passing from Optic Nerve into Vitreous Chamber, Arch. Ophth. **10**:824 (Dec.) 1933.

2. O'Brien, C. S., and Allen, J. H.: Myiasis Interna Anterior, Am. J. Ophth. **22**:996, 1939.

3. McBride, J. R. B.: Myiasis, Brit. M. J. **1**:672, 1939.

(Footnotes continued on next page)

full of minute larvae running about over the cornea and deep into the conjunctival folds. Some of these were manually removed, and then a 2 per cent solution of silver nitrate was instilled without any deleterious effect on the larvae. It was necessary to remove the larvae one by one with a forceps. The patient was hospitalized over night, and on the advice of an entomologist the eye was bathed continuously in mineral oil. Ice compresses were used to relieve congestion and edema. The next morning several more larvae were removed, but their activity had markedly decreased. Fifty larvae had then been removed from the cul-de-sac of the right eye. No evidence of intraocular infestation was present then, nor has any been manifested since. No larvae appeared from the puncta. The conjunctivitis cleared up readily, and no permanent damage resulted.

COMMENT

One larva was mounted by Mr. M. L. Bobb, assistant entomologist, Piedmont Fruit Research Laboratory, of Charlottesville, Va. It was sent to the United States Bureau of Entomology in Washington, D. C., where a diagnosis between a larva of Oestrus ovis and a larva of a species of Cephenomyia (deer bot) could not be definitely made. However, since Oestrus ovis larvae have on various occasions been reported in the medical literature as having been found in the human eye, it was thought that the specimen represented these larvae. No record of a similar occurrence of larvae of Cephanomyia could be found.

Oestrus ovis is the sheep gadfly, and the larva is usually 1 mm. long, with an elongated, oval body, broad in front and gradually attenuated in the rear. It is actively motile and uses its hooks for attachment to mucous membranes. The larvae are deposited by the fly while it is flying. The flies are widely distributed over the country used for sheep raising and are sometimes the cause of the death of a sheep. The larvae are deposited in the nose of the sheep, and they find their way into the sinuses, where growth takes place, and they finally fall out on to the ground to complete the cycle.

CONCLUSION

Six cases of conjunctival myiasis are reported in the American literature. No serious consequences are expected from external infec-

4. Wright, R. E.: Myiasis with Chronic Degeneration of Cornea, Am. J. Ophth. **10**:411, 1927.

5. Sniderman, H. R.: Larval Conjunctivitis, Am. J. Ophth. **22**:1253, 1939.

6. Stark, H. H.: Ophthalmia Myiasis Externa Due to Larvae of Oestrus Ovis, J. A. M. A. **81**:1684 (Nov. 17) 1923.

7. Lyon, M. W.: Conjunctival Myiasis Due to Oestrus Ovis, Am. J. Ophth. **18**:547, 1935.

8. Schenck, C. P.: Ocular Myiasis, Am. J. Ophth. **13**:801, 1930.

9. Bedsole, J. E., and Neal, R. D.: Ophthalmomyiasis, Tr. M. A., Alabama **63**:253, 1930.

10. Mustard, R.: Case of Ocular Myiasis, Canad. M. A. J. **37**:67, 1937

tion. If the condition occurs frequently the patients certainly do not seek advice, as this is the first case we have noted in forty-two years of practice. Treatment consists of removal of the larvae and instillation of mineral oil. Slit lamp and careful ophthalmoscopic examination should be made to rule out intraocular infestation.

104 East Market Street.

SEASONAL VARIATIONS IN PHOSPHOLIPID CONTENT OF CRYSTALLINE LENSES

WITH SPECIAL REFERENCE TO CLIMATOLOGIC INFLUENCES

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IOWA CITY

In two previous publications [1] experiments were described showing that the cholesterol and the phospholipid content of crystalline lenses varied more or less inversely to each other and that the cholesterol content varied also inversely to the humidity of the atmosphere. Opinion was then expressed that consequently the phospholipids should vary directly with humidity. Analyses for phospholipids of cataractous lenses from patients all of whom resided in the state of Iowa were made for twenty-five consecutive months beginning with November 1933 and ending with November 1935. The ages of the subjects from whom the lenses were obtained varied from 31 to 87 years, with an average of 68 years. In all, 240 lenses, extracted by the intracapsular method, were analyzed. The analyses were carried out by a modification of Whitehorn's colorimetric method,[2] and the phospholipids were calculated as lecithin. The number of lenses collected each month varied from 2 to 27.

The phospholipid values, expressed in both per cent and absolute amounts on the basis of wet weight of the lenses, were plotted against the climatologic data reported for the state of Iowa for the period involved by the United States Department of Agriculture at Des Moines, Iowa.[3]

The relation of phospholipids to atmospheric influences is more complex than that of cholesterol. Sunshine appears to be antagonistic to the phospholipids, whereas temperature and humidity influence them largely in a positive way. But temperature and humidity, being for the

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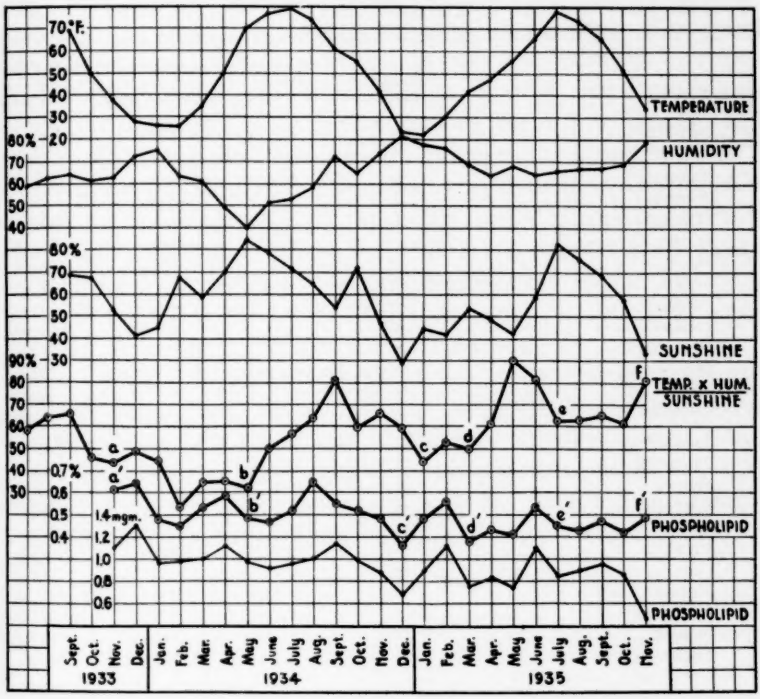
From the Department of Ophthalmology, College of Medicine, State University of Iowa.

1. Salit, P. W.: Seasonal Variations in the Lipid Content of the Crystalline Lens, Arch. Ophth. **18**:403-410 (Sept.) 1937; Seasonal Variations in Lipid Content of Crystalline Lenses, with Special Reference to the Influence of Sunshine and Humidity, ibid. **25**:32-35 (Jan.) 1941.

2. Salit, P. W.: Phospholipid Content of Cataractous Human Lenses, Brit. J. Ophth. **19**:663-671, 1935.

3. Reed, C. D.: Climatological Data, United States Department of Agriculture, Weather Bureau, Iowa Section, Des Moines, Iowa, November 1933—November 1935.

most part antagonistic to each other, affect the phospholipid curve in such a way that as soon as the curve gets out of the control of the one it immediately follows the other. But this change in its last analysis is determined by the sunshine curve, as temperature and humidity represent to a large extent the positive and the negative phase of sunshine, respectively. The changes in the phospholipid curve are therefore the resultant of the combined influences of temperature, humidity and sunshine, varying directly with the product of the first two and inversely



Changes in phospholipid content of crystalline lenses with relation to temperature, humidity and sunshine.

with the third. When the combined effect of the climatologic influences is expressed by a single set of values by multiplying those of temperature and humidity and dividing the products by those of sunshine, a curve is obtained which strikingly resembles the phospholipid curve, as seen from the partial curves *ab-a'b', bc-b'c', cd-c'd', de-d'e' and ef-e'f'*. The comment that was made in a previous publication on certain irregularities between the sunshine and the total lipid curve and the humidity and the cholesterol curve applies also to the present study, showing them to be largely due to such side influences as occupation, exercise, eating habits

and general health as well as to certain errors inherent in the methods of securing the monthly averages for both the chemical and the climatologic data.

Cholesterol, being hydrophobic and varying inversely with humidity, and lecithin, being hydrophilic and varying directly with the product of temperature and humidity and inversely with sunshine, appear thus, as suggested previously, to be vitally concerned with the water balance and consequently with the temperature regulation of the tissues. Besides

Seasonal Variations in Phospholipid Content of Crystalline Lenses

Year	Month	Number of Lenses	Average Age of Subjects	Average Amount of Lecithin	
				Mg. per Lens	Per Cent
1933	November	5	62.8	1.080	0.610
	December	6	76.2	1.332	0.628
1934	January	2	73.0	0.948	0.476
	February	5	54.4	0.976	0.456
	March	5	62.0	1.037	0.532
	April	9	70.9	1.116	0.569
	May	6	69.2	0.973	0.477
	June	3	68.3	0.935	0.466
	July	3	62.0	0.960	0.523
	August	2	74.0	1.041	0.640
	September	12	67.0	1.105	0.545
	October	7	69.4	0.987	0.514
	November	11	72.2	0.892	0.435
	December	6	61.3	0.694	0.365
1935	January	7	66.9	0.915	0.484
	February	11	68.3	1.100	0.543
	March	17	62.4	0.776	0.375
	April	13	70.3	0.825	0.434
	May	27	69.5	0.742	0.412
	June	20	72.8	1.070	0.520
	July	13	63.6	0.847	0.451
	August	14	69.7	0.866	0.426
	September	13	67.8	0.951	0.456
	October	18	67.4	0.848	0.431
	November	5	72.2	1.052	0.464

being hydrophobic, cholesterol has the ability to increase the surface tension and constrict the blood vessels [4] and is therefore superbly suited as a water barrier in the tissues, guarding them from loss of heat by keeping down evaporation. The phospholipids, on the other hand, besides being hydrophobic have the ability to lower the surface tension

4. Dresel, K., and Sternheimer, R.: Die Rolle der Lipoide im vegetativen System: II. Mitteilung. Die Wirkung kolloidaler Lecithin-und Cholesterinlösungen auf das Laewen-Trendelenburgsche Froschpreparat, Ztschr. f. klin. Med. **107**:759-784, 1928. Deckwitz, R.: Lipoidantagonismen: Versuch einer physikalisch-chemischen und biologischen Analyse der Funktionen und Funktionsmodi lipoider Zellbausteine, Ergebn. d. Physiol. **32**:821-974, 1931.

of the body fluids and to relax the blood vessels [4] and evidently other tissues, and thus they are preeminently suited as attractors and absorbers and conveyors or distributors of water in the tissues; they promote evaporation when the body is threatened by excessive heat.

SUMMARY

Seasonal variations in the phospholipid content of 240 cataractous human lenses were studied over a period of twenty-five consecutive months beginning with November 1933 and ending with November 1935. The subjects were all residents of the state of Iowa and varied in age from 31 to 87 years, with an average of 68 years. The monthly phospholipid averages were plotted against the monthly averages of temperature, humidity and sunshine as reported during that period for the state of Iowa by the weather bureau of the United States Department of Agriculture at Des Moines. In general the phospholipids tend to be positively influenced by temperature and humidity but negatively by sunshine. The climatologic influences on the phospholipids may be reduced to a single set of values by dividing the product of the temperature and humidity values by the sunshine values. When the resultant values are plotted in the form of a graph, a curve is obtained that bears a striking resemblance to the phospholipid curve.

It is pointed out that the phospholipids in conjunction with cholesterol, on account of their mutually antagonistic behavior toward atmospheric conditions and their respectively hydrophilic and hydrophobic properties as well as their mutually antagonistic physiologic reactions, must be vitally concerned with the water balance and consequently with the temperature regulation of the tissues.

PARALLACTIC ANGLE IN BINOCULAR DEPTH PERCEPTION

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Binocular perception of depth or of relative distance involves the working of several factors, among which the parallactic angle is one. Whether the parallactic angle is the most important element, as some authorities claim, or the least important element, as others claim, it is certainly one of the elements involved. The angle results from a change in the amount of convergence used when both eyes change fixation from one point to another. It is, however, not a simple angle; it is rather what may be called a composite angle and a dynamic angle, for reasons which will be shown. It is the composite and dynamic character of the parallactic angle which makes it confusing and difficult to understand. The angles commonly used in ophthalmology are simple and static and require merely the visualization of two lines meeting at a point, e. g. the visual angle, formed by two lines from the extremities of an object to the nodal point, and the angle gamma, formed by the optic axis and the fixation axis at the center of rotation.

To evaluate the parallactic angle it is necessary to keep in mind the two types of binocular movement which enter into the formation of the angle. These two types are (1) the version movements, in which the two eyes move in the same direction—right, left, up or down, and (2) the vergence movements, in which the eyes move in opposite directions, one to the right and the other to the left. Of the version movements I shall touch on only two, dextroversion—both eyes to the right—and levoversion—both eyes to the left. The vergence movements consist of convergence and divergence movements. The eyes occasionally make pure version movements and pure vergence movements, but usually these movements are combined. But whether the movements are simple or combined they are controlled by the cardinal principle of equality of innervation to each of the two eyes. That is, when there is a version innervation there is as much innervation sent to the right eye as to the left eye, whatever the degree of actual movement, and likewise when there is a vergence innervation there is as much innervation sent to the right eye as to the left, whatever the degree of actual movement. The bearing of this principle of equality on the parallactic angle can be shown best by a few diagrams.

In *View A* of the accompanying illustration, *R* and *L* represent the right and the left eye shown only by their centers of rotation. *A* and *B* are two fixation points. For ease of identification the right visual axis is drawn as a solid line and the left visual axis as a broken line. When the eyes move from *A to B*, the latter on the midline, both eyes make a pure convergence movement. Angle *R* and angle *L* are the angles through which both eyes turn when they change fixation from *A* to *B*. Angles *R* and *L* are equal numerically though opposite in sign, since they are produced by rotation in opposite directions, as shown by the arrows. An angle may be positive or negative, just as a lens may be positive or negative. In general the parallactic angle is equal to the algebraic difference between the angles *R* and *L*. In equation form *P* equals *R* minus *L*. But the relation between *P*, *R* and *L* may be expressed arithmetically, too. When *R* and *L* have the same sign one takes the numerical difference. When *R* and *L* have different signs one takes the numerical sum. In this instance *R* and *L* have different signs; therefore, the parallactic angle equals the numerical sum of *R* and *L*. For example, if *R* equals 2 degrees (+ 2 degrees), and *L* equals 2 degrees (— 2 degrees), *P* equals 4 degrees.

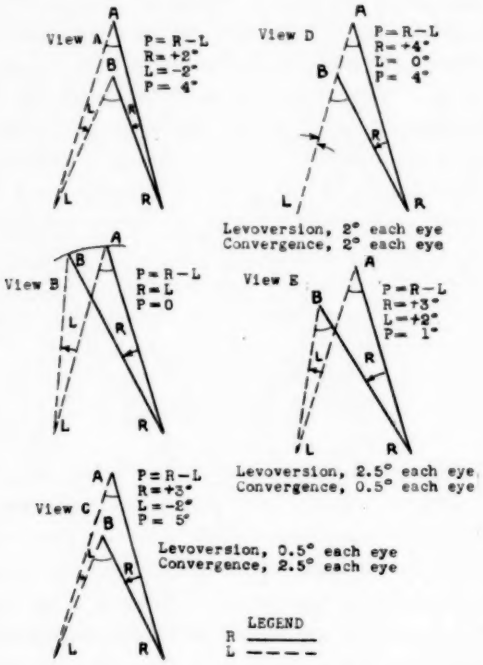
In *View B* of the illustration, as the eyes move from *A* to *B*, if *B* lies on the circumference of a circle determined by *A*, *R* and *L*, the so-called isogonal line of Maddox, the eyes make a pure version movement, a levoversion. Angles *R* and *L* are equal and of the same sign.

The parallactic angle equals the difference between *R* and *L*, and, since these are equal, *P* equals zero. There is no vergence movement involved, the parallactic angle is zero and point *B* appears to the left but at the same distance as point *A*.

In *View C*, as the eyes move from *A* to *B* there is a combined movement of levoversion and convergence. Although the innervations for the two types of movement are exactly equal for the two eyes, the actual movements and the angles are not equal. One can analyze what happens.

Suppose *R* equals 3 degrees and *L* equals 2 degrees; then there are a levoversion innervation of ½ degree for each eye and a convergence innervation of 2½ degrees for each eye. In the right eye the levoversion innervation of ½ degree and the convergence innervation of 2½ degrees, which also calls for a movement to the left, combine to produce an actual rotation of 3 degrees (to the left). But in the left eye the levoversion innervation of ½ degree is neutralized by the convergence innervation of 2½ degrees, which calls for a movement to the right, the result being an actual rotation (to the right) of only 2 degrees. In this instance, too, the parallactic angle *P* equals *R* — *L*, and since the angles are of opposite signs *P* equals the numerical sum; i. e., *P* equals 5 degrees. This is the sum of the convergence innervation to the two eyes.

In *View D,* as the right eye moves from *A* to *B* (*B* lying on the visual axis of the left eye) the convergence innervation to the left eye is completely neutralized by the levoversion innervation to the left eye; therefore, angle *L* equals zero. In the right eye the convergence innervation is added to the levoversion innervation, making angle *R* equal to the sum of the two. The parallactic angle *P* equals *R* minus zero, equals *R*. If the levoversion innervation, for example, is 2 degrees for each eye and the convergence innervation is 2 degrees for each eye, *P* equals 4 degrees.



Diagrams demonstrating the dynamic composite character of the parallactic angle.

In *View E,* as the eyes move from *A* to *B* the angle *R* is greater than the angle *L,* because angle *R* is made up of the sum of the levoversion and the convergence angle whereas angle *L* is made up of the difference between the levoversion and the convergence angle. Since *R* and *L* are of the same sign, the parallactic angle *P* equals the numerical difference. If *R* equals 3 degrees and *L* equals 2 degrees, *P* equals 1 degree. This, too, is the total convergence innervation sent to both eyes.

If the point *B* in my diagrams were taken to the right of point *A,* one would get exactly the same numerical results, except that one would

have to deal more with negative angles. The signs of the angles may be neglected and the values taken arithmetically, as was mentioned before. But for a fuller appreciation of P, it is best to use the relation P equals $R - L$ algebraically. If in *View B*, B were to the right of A, R would equal -2 degrees and L would equal -2 degrees. The algebraic difference would still be zero. In *View C*, if B were taken to the right of A as much as it is now to the left, R would equal $+2$ degrees and L would equal -3 degrees. The algebraic difference would still be $+5$ degrees. In *View D*, if B were taken on the visual axis of the right eye, R would equal zero and L would equal -4 degrees. The algebraic difference would still be $+4$ degrees. Finally, in *View E*, if B were taken as much to the right of A as it is now to the left, R would equal -2 degrees and L would equal -3 degrees. The algebraic difference would still be $+1$ degree. The angle P will always come out positive when there is a convergence innervation involved and negative when there is a divergence innervation involved.

Now it can be shown that in all cases the actual numerical value of the angle P is the difference between angles A and B; i. e., P equals $B - A$. These angles, formed at the fixation points A and B by the two visual axes, are the angles of convergence (in a passive sense) at points A and B. Angles A and B are called the binocular parallax at A and the binocular parallax at B, respectively. Therefore it can be said that the binocular parallactic angle equals the difference between the binocular parallax at the two points of fixation. This equation, however, gives merely its numerical value, not the real significance of the angle P. In view of the preceding illustrations, the parallactic angle, P, may be defined as the composite angle through which the two visual axes turn, actually or potentially, when changing fixation from one point to another. By composite angle I mean the numerical sum or difference of R and L, depending on whether the angles R and L have opposite signs or the same sign. The parallactic angle in a dynamic sense is the motor expression of the vergence innervation. One may use the same diagrams to show the parallactic angle for divergence innervation by merely changing fixation from B to A and changing the direction of the arrows. If the relation P equals $R - L$ is used algebraically, P will come out minus, denoting a divergence innervation.

The threshold, or minimum, parallactic angle necessary for depth perception has been found by some investigators to be as low as 2 seconds of arc under favorable conditions of observation. A conservative estimate places the normal parallactic angle between about 5 and 12 seconds of arc. In the depth perception tests of the United States Army and Navy Air Corps a parallactic angle of more than 12 seconds is cause for rejection. A maximum linear displacement of 30 to 35 mm. at 6 meters,

which is the limit for acceptance, measures an angle of about 10 to 12 seconds. It may be noted that the angle varies to a slight extent with the candidate's interpupillary distance and that a large pupillary distance is an advantage in depth perception. For a given linear displacement the parallactic angle is less for a small than for a large pupillary distance. Thus if two candidates, one with a pupillary distance of 58 mm. and the other with a pupillary distance of 66 mm., pass the test with the same linear displacement, for example, 25 mm., they will be rated alike but the former will have a slightly higher degree of depth perception than the latter as measured by the parallactic angle.

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FIBROMA OF THE ORBIT

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Among the proved tumors of the orbit fibroma is rare. Reese [1] reported 174 consecutive cases of unilateral exophthalmos, finding only 1 case of fibroma, which arose from a tendon sheath of an extraocular muscle. Schreck [2] reported 259 cases of various types of orbital tumors, but no cases of fibroma were included in his series. The fibroma in the case presented here was proved not only by histologic observations but by the fact that the patient had had no recurrence five years after the growth was removed surgically.

Miss H. D., aged 23, first consulted one of us on April 13, 1936. She had been referred by her family physician, Dr. R. L. Tschopp, who reported "a recent swelling of the left eye and a slightly enlarged, but inactive, thyroid." The patient said that the vision in her left eye was cloudy and that the eye had been "swollen" during the past two months. Lately she had had headaches on the left side. There was no history of injury to the head. The family history was unimportant.

Vision was 20/20 in each eye. With homatropine cycloplegia, refraction showed the following error: right eye, +0.25 D. cyl., axis 90; left eye, +0.37 D. sph. With a millimeter rule the protrusion of the right eye measured 18 mm. and that of the left eye 21 mm. The left eye moved freely in its orbit; there was no bruit, although there was a faint suggestion of pulsation when the eye was viewed from the side with a loupe. A firm mass was felt close to the globe in the lower temporal quadrant. It seemed to move forward when the eye was turned inward. The fundus showed papilledema with 1.5 D. of elevation, and a flame-shaped hemorrhage was present below the disk. The near point of convergence was 90 mm. There were esophoria for distance vision of 2 degrees and exophoria for near vision of 4 degrees. Hyperphoria was not present. The visual field of the left eye was normal for a $^{2}/_{1.000}$ mm. white test object, but the blindspot was twice the size that of the right eye. The right fundus, field and blindspot were all normal. The patient was sent to Dr. E. C. Koenig for roentgenograms of the orbits. He reported an increased density in the left orbit, especially in the outer side as compared with the same area in the right orbit. The sinuses were clear. The sella turcica was small, but otherwise there was nothing unusual. Three weeks later vision

From the Private Eye Service and the Department of Pathology, Buffalo General Hospital.

1. Reese, A. B.: Orbital Tumors: Part I, Am. J. Ophth. **24**:386 (April) 1941.

2. Schreck, E.: Zur Klinik und pathologischen Anatomie der Orbitaltumoren, Klin. Monatsbl. f. Augenh. **103**:1 (July) 1939.

in the left eye was still 20/20. The optic disk appeared as before. The protrusion of the left eyeball measured 22 mm., and it was definitely noticeable that as the patient adducted the left eye the mass bulged the lower lid outward. Several roentgen ray treatments were given by Dr. Koenig during the next two weeks. On June 10 (fifty-eighth day of observation) the left eye protruded 26 mm. There was a small area of chemosis at the outer canthus, and 2 D. of elevation of the optic disk was noted. The flame hemorrhage below the disk had disappeared. Vision was still 20/20.

At the Buffalo General Hospital on June 10, with the patient under local infiltration ansthesia, an attempt was made to obtain a biopsy specimen of the mass through an incision in the conjunctiva in the inferior temporal quadrant directly over the tumor. An external canthotomy was done. A thick, loose layer of tissue, probably thickened Tenon capsule, was incised, a white, firm tumor being exposed. It was grasped with a toothed forceps and seemed freely movable. As it was drawn forward, so that a small piece of tissue might be removed, it came forward freely. The patient squeezed her eyelids suddenly, because of pain, and the tumor popped out on her cheek. It was an egg-shaped mass 2.4 cm. long, 2 cm. wide and 1.8 cm. thick. There were several filmy, threadlike attachments extending back into the orbit. These were clipped with scissors and the wound closed. At the conclusion of the operation ocular movements were normal, and the patient stated that vision was clear. She left the hospital two days later.

Twenty-two days postoperatively, vision was 20/20 in each eye without correction. A bandlike scar running between the globe and the orbital margin had formed, and this restricted the movements of the left eye slightly, causing diplopia when the patient looked down and to the right. The two eyes protruded equally (18 mm.). Fusion was present with the stereoscope. Massage of the fibrous band was instituted. Fifty-six days postoperatively, there was no limitation of the movements of the left eyeball, and no diplopia was present. The disk margins were still blurred, but the blindspot was not enlarged. One hundred and thirty-seven days postoperatively, vision was still normal, and there was 1 degree of right hyperphoria but no symptom of eye strain. The optic disks looked alike. The fields for a $\frac{2}{1.000}$ mm. white object were normal, and the blindspots were equal. It was noted now that the protrusion of the right eye was 18 mm., while that of the left eye was only 17 mm.

On Aug. 12, 1941 (five years and two months after the operation), the eyes appeared normal (fig. 1). There was no exophthalmos in either eye—the protrusion of each eye measuring 18 mm. The eyegrounds were normal. Vision was 20/20 in each eye. Both eyes moved freely in all directions, and there was no sign of recurrence of the tumor. The patient looked healthy and felt well.

A description of the tumor mass by one of us (K. L. T.) is as follows:

The entire tumor was embedded in celloidin. The report which is given here is a description of the observations on a cross section in a horizontal plane through the entire tumor at its largest diameter. The sections were stained with hematoxylin and eosin and according to the Van Gieson method (fig. 2).

The tumor was well encapsulated. It was of a decidedly fibrillar structure, especially in the center. In a Van Gieson preparation, there was a rather dense network of slightly hyalinized connective tissue fibers which seemed to radiate toward the capsule. The formation of fibers was much less marked along the capsule. They were there rather thin except in one area, where they appeared somewhat thicker, and in several places they were arranged in more or less parallel

layers. In hematoxylin-eosin stains the cellularity was rather marked, even within the more central portions, where hyalinized connective tissue fibers were present. It appeared as though the cells with their fibers were traversing the tumor in different directions, having in some places a longitudinal, in others a more oblique, and in still others a more or less vertical, course. The shape, form and size of these cells were those of fibroblasts with clear spindle-shaped or slightly polygonal nuclei and with distinct nucleoli, usually only one in each cell. The production of mesenchymal fibers was clear, especially in the spindle-shaped portions. In some of them beginning hyalinization could be recognized. Entirely normal mitotic figures could be seen rarely; no more than two could be distinguished throughout one section. The tumor contained a fair number of thin-walled capillaries, some of which appeared decidedly ectatic. In the more peripheral areas there was some fluid matter between the isolated spindle cells and the fibroblastic elements, which produced the picture of somewhat irregular edema. In a few areas near the

Fig. 1.—The patient five years and two months after the operation.

capsule there were recent hemorrhages surrounding markedly injected capillaries and small veins.

The following features pointed to diagnosis of a benign mesenchymal tumor of the type called fibroma or, better, fibroblastoma: first, the arrangement of the cells, their form and nuclei and the relation of nucleus to cytoplasm; second, the fibers, the whole variety of young, somewhat ovoid and spindle-shaped cells, and, third, the typical long fibroblastic homogeneous, collagenous substance, which gave the typical staining reactions of collagenous fibers. The relation between the blood vessels and the tumor parenchyma clearly pointed in the direction of fibroblastoma. The number of capillaries was moderate, and in the more dense central portions they appeared compressed or reduced. There was nowhere a picture which would justify the diagnosis of a benign

mesenchymal mixed tumor in the sense of angiofibroma, nor were fat cells seen.

Finally, in considering other differential diagnostic possibilities, we wish to stress that the entirely regular, fibrillar structure present throughout the tumor, the absence of even small nerve fibers at both poles of

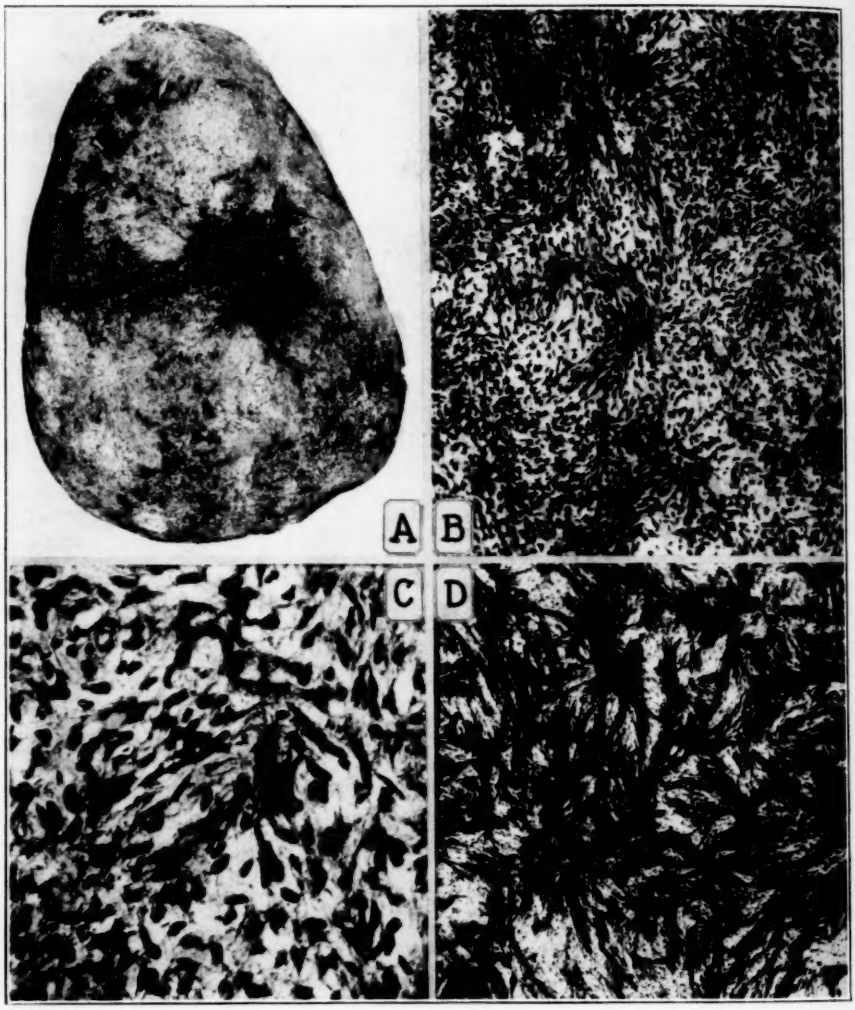

Fig. 2.—*A*, low power view through the entire tumor. The hyalinized center appears darker than the rest of the tumor. *B*, one of the many typical fibromatous structures. There are few collagenous fibers, especially in the upper field. *C*, high power view of the cellular structures in the tumor, showing slight edema between individual fibroblasts. *D*, Van Gieson preparation, showing the markedly hyalinized center of the tumor with radiating, interlacing hyaline collagenous bundles.

the tumor and especially the absence of peculiar palisade or bandlike arrangements of the spindle cells or fibrillas are sufficient proof against a neurogenic tumor, such as benign neurinoma or so-called neurofibroma. Minor variations in shape and size of cells and nuclei were mostly caused by the peculiar structure of the tumor, in which the individual cellular units and the more differentiated mesenchymal fibers were growing through the tumor in different directions. We cannot see or speak of atypical cells or nuclei. The small number of mitotic figures can be seen in any benign expansively growing blastoma. The diagnosis, for all the reasons given, was benign fibroblastoma.

Birch-Hirschfeld [3] collected about 30 cases from the literature. In reviewing the published reports available we discovered 16 proved cases in which the tumor was primary in the orbit, as in the case we are reporting. Many cases have been reported without a histologic diagnosis. Cases reported by Pim,[4] Triplett,[5] Story [6] Schreiber [7] and Viets [8] are not included because microscopic proof of fibroma was not given. We have not included such cases as Solomon's,[9] in which there was fibroma of the external rectus muscle; that of Teulières and Beauvieux,[10] in which the tumor originated in the tendon sheath of the superior rectus muscle and invaded the sclera, and Cerckez' [11] case, which was an instance of pure fibroma of the sclera. The pathologic process in the case of Schmidt,[12] in which fibroma of the sclera was growing inward and detaching the retina, was undoubtedly the same as in other cases of fibroma, but the clinical picture was different. This can be said also of the case reported by Dandy,[13] in which the fibroma arose in the skull

3. Birch-Hirschfeld, A., in Schieck, F., and Bruckner, A.: Kurzes Handbuch der Ophthalmologie, Berlin, Julius Springer, 1930, vol. 3, p. 78.

4. Pim, L. T.: Extirpation of a Large Fibrous Tumor from the Orbit with Complete Restoration of Vision and Motion to the Eyeball, St. Louis M. & S. J. **17**:488 (Nov.) 1859.

5. Triplett, W. H.: A Case of Extreme Exophthalmos, the Result of Fibro-Fatty Tumor of the Orbit: Operation, Recovery, Boston M. & S. J. **82**:98 (Feb. 10) 1870.

6. Story, J. B.: Rare Tumor of the Orbit, Ophth. Rev. **3**:245, 1884.

7. Schreiber: Berl. klin. Wchnschr. **43**:696 (Oct. 27) 1884.

8. Viets, B. B.: An Orbital Tumor, J. Ophth., Otol. & Laryng. **4**:39 (Jan.) 1892.

9. Solomon, J. V.: Fibro-Plastic Tumor of the Rectus Oculi in a Child, Brit. M. J. **1**:49 (Jan. 4) 1868.

10. Teulières, M., and Beauvieux, J.: Fibrome de la sclérotique, Arch. d'opht. **2**:107 (Dec.) 1938.

11. Cerckez, V.: Le fibrome de la sclérotique, Ann. d'ocul. **175**:390-396 (May) 1938.

12. Schmidt, J.: Fibrom der sklera, Arch. f. Ophth. **138**:748-759, 1938.

13. Dandy, W. F.: Results Following the Trans-Cranial Operative Attack on Orbital Tumors, Arch. Ophth. **25**:194-195 (Feb.) 1941.

and perforated the orbital roof. Related tumors, such as fibrohemangioma and neurofibroma, are not included because the basic pathologic change is different from that of pure fibroma even though the clinical picture

Cases of Fibroma Primary in the Orbit

Author	Year Reported	Sex of Patient	Age of Patient	Duration of Disease	Age at Onset	Microscopic Examination
Williams, C.: J. Brit. Ophth. **1**: 59, 1864	1864	♂	30	15 yr.	15	Yes; no details
Schiess-Gemuseus [18]	1868	♂	35	7 yr.	28	Yes; fibroma with lipoid and cystic degeneration
Perls: Berl. klin. Wchnschr. **2**: 355, 1874	1874	?	1 day	Patient lived 24 hr.	Birth	Yes; fibroma
Reid, T.: Tr. Ophth. Soc. U. Kingdom **9**: 51, 1889	1889	..	75	¾ yr.	74	Yes; no details; fibroma with vascular capsule
Tornatola, S.: Ann. di ottal. **19**: 491, 1890	1890	♂	30	16 yr.	14	Yes; myxofibroma
Grossman: Liverpool Med.-Chir. J. **24**: 369, 1904	1904	Not stated	Not stated	Not stated	Not stated	Yes; hard, dense fibroma; sarcomatous ?
Chevallereau, A., and Chaillous, J.: Klin. Monatsbl. f. Augenh. **42**: 166, 1904	1904	♀	18	8 yr.	10	Fibroma
Roy [16]	1908	♂	14	3 yr.	11	Yes; fibroma with calcification
Ring, O.: Tr. Am. Ophth. Soc. **12**: 205. 1909	1909	♂	30	6-7 yr.	23-24	Fibrous tissue with fibroblasts
Steiner: Centralbl. f. prakt. Augenh. **33**: 257, 1909	1909	♀	12	12 yr.	Birth	Pure fibroma with calcification
Teulières [17]	1913	♀	34	8 yr.	28	Fibroma; hard, white
Coover, H. D.: Am. J. Ophth. **1**: 341, 1918	1918	♂	11	Not stated	..	Yes; fibroma
Giri: Internat. Ophth. Cong. **2**: 503, 1929	1929	♀	52	15 yr.	37	Yes; smooth, shiny, pale; resembled neurofibroma; whorls and interlacing bundles
Stokes and Bowers [14]	1934	♂	25	4 yr.	21	Yes; round, rather soft, mature fibroma; tissue cells in interlacing strands
Sironi, L.: Boll. d'ocul. **18**: 881, 1939	1939	♀	8	2 yr.	6	Pure fibroma mixed with inflammatory tissue
Ellett [19]	1941	♂	20	12 yr.	8	Yes; hyalinized fibrous tissue; firm, gray mass

is similar. Our clinical knowledge of this disease is based only on published case reports; so we feel that a study of the literature is necessary in a report of any rare case.

From a study of the accompanying table some conclusions can be drawn about the disease. The tumor occurred in most cases (56.2 per cent) before the age of 16 and in 81.2 per cent before the age of 29.

Collected from the Literature

Size of Tumor	Operation	Tumor Encapsulated	Tumor Inside Cone	Attachments	Location	Comment
44 by 44 by 25 mm.	Evisceration of orbit	Yes	Yes	None	Not stated	Optic nerve 2 in. long; globe ruptured spontaneously; no history of injury
Large; proptosed eye 25 mm.	Upper lid laid back; internal rectus muscle cut	No	Not stated	Orbital roof, posterior part of globe and optic nerve	Upper-inner quadrant	Definite history of injury to brow preceding tumor by 1 year
20 mm. in diameter	None	No	No	External rectus muscle, periosteum of roof	Upper-outer quadrant	Tumor involved bone and dura
Walnut	.....	Yes	No	Another mass attached to roof felt later	Near lacrimal gland	No proptosis
58 by 44 mm.; filled orbit	Brow incision; levator severed	Yes	No	Tenon's capsule	Inner-upper quadrant	Ptosis resulted; biopsy of no value
"Large"	Evisceration of orbit; eye blind	Not stated	Not stated	Not stated	Probably upper half	Tumor pushed eye down and forward; no recurrence in 4½ years
Almond	Not stated	Not stated	Probably not	Periosteum of roof	Upper-outer quadrant	No recurrence in 6 mo.; tumor followed injury 2 years earlier
Filled whole orbit; 55 Gm.	Evisceration of orbit; eye enucleated previously with small tumor	Yes	Probably not	To almost all orbital periosteum	First tumor removed from top of orbit	Patient burned eyelids at age of 3
25 by 38 mm.	Eye and mass removed	..	Yes	Apex of orbit	Upper-inner quadrant	Optic nerve atrophy
40 by 35 by 35 mm.	Cutaneous incision	Yes	Probably not	Nerve and blood vessel only	Entire orbit filled	Eye protruded 30 mm. in front of orbital margin; vision, light projection
20 by 10 mm.	Cutaneous incision	Yes	No	Periosteum	Upper-outer quadrant	Tumor followed injury 12 years earlier
35 by 25 mm.; kidney shaped	Evisceration of orbit; "Krönlein operation might have saved the eye"	Not stated	Not stated	Optic nerve, periosteum and optic foramen	Temporal side; filled whole side of orbit	
30 mm.	Transconjunctival; patient died 15 mo. later, cause of death not stated	Yes	Not stated	Floor of orbit	Below and temporally	Diplopia followed, but relieved by operation on muscles
15 mm. in diameter; round	Brow incision; Krönlein operation easier	Yes	No	Attached to periosteum at one point	Nasal side; supraorbital notch beneath upper lid	Nasal fracture in childhood; disease began with ptosis
Large chestnut	Through skin of brow	Yes	No	Levator, periosteum of roof of orbit, lacrimal glands, external rectus muscle	Upper half of orbit	Marked ptosis; no relapse in 3 yr.; disease began with inflammatory symptoms and ptosis
35 by 20 by 25 mm.	Through skin; easy	Yes	Not stated	None	Upper-inner quadrant; reached the apex	Eye down and out; roentgen ray therapy had no effect

Eight of the patients were male and 5 were female, but the sex of 3 was not stated. In 2 cases fibroma was present at birth. In only 1 was the growth stated to be recurrent, owing to incomplete removal. One

patient died fifteen months after operation, but the cause was not stated. The tumor was encapsulated in 63 per cent, being described as not encapsulated in only 2; no mention was made of a capsule in 4 cases. Whether or not the tumor was inside the muscle cone was stated in only 3 cases, and, considering our case also, one can say that sometimes the tumor lies entirely within the muscle cone, although in 56.2 per cent it was stated (or could be assumed to be) outside the muscular cone. Nearly 69 per cent of the tumors stated to be outside the muscle cone were attached to the periosteum, but 3 had no attachments. Occasionally the tumor was adherent to the optic nerve, lacrimal gland or Tenon's capsule. The tumor was in the upper half of the orbit in 75 per cent of the cases, being in the upper-inner quadrant in 5, in the upper-outer quadrant in 4 and in the whole upper half in 3. Some observations similar to these were drawn by Stokes and Bowers,[14] who are the most recent authors to review fibroma of the orbit in the United States, and by Benedict.[15]

The surgical story revealed is interesting. In slightly over 31 per cent of the cases the tumor and the eye were enucleated or the orbit was eviscerated, or both, and nearly 44 per cent of the tumors were removed through cutaneous incisions in the brow or upper lid. Only 1 was removed through the conjunctiva. Injury was reported 4 times (in 25 per cent of the series). In the present era this factor is worthy of consideration. The relation of the tumor to the injury might be questioned in the cases of Roy,[16] Teulières [17] and Stokes and Bowers,[14] but one cannot deny the reported fact in them. Schiess-Gemuseus [18] was sure that injury was the cause of the tumor in his case, and his argument is most convincing.

Both Benedict [15] and Ellett [19] mentioned the ineffectiveness of roentgen ray therapy, which we observed in the case here reported. Elschnig [20] has called attention to the fact that a tumor in the muscle cone causes early changes in the optic disk, a fact which was clearly illustrated by our case. Few patients have been operated on more easily than ours,

14. Stokes, W. H., and Bowers, W. F.: Pure Fibroma of the Orbit, Arch. Ophth. **11**:279 (Feb.) 1934.

15. Benedict, W. L.: Diseases of the Orbit, in Berens, C.: The Eye and Its Diseases, Philadelphia, W. B. Saunders Company, 1936, p. 337.

16. Roy, J. N.: Fibrome calcifiant de l'orbite, Ann. d'ocul. **140**:33, 1908.

17. Teulières, M.: Le fibrome de l'orbite, Arch. d'opht. **33**:236 (April) 1913.

18. Schiess-Gemuseus: Grosses cystoides Fibrom der Orbita, hochgradiger Exophthalmus, Heilung mit Erhaltung des Bulbus, Arch. f. Ophth. (pt. 1) **14**:87, 1868.

19. Ellett, E. C.: Unilateral Exophthalmos, J. A. M. A. **116**:1 (Jan. 4) 1941.

20. Elschnig, A.: Operations for Tumors of the Orbit, Surg., Gynec. & Obst. **45**:65 (July) 1927.

which confirms the contention of Reese [21] and Dunnington [22] that the transconjunctival route is often most satisfactory.

SUMMARY

A unique proved case of rapidly growing fibroma (fibroblastoma) of the orbit has been described. It has been presented along with other proved cases found in the literature, and some of their common characteristics are noted. We feel that the most important points which our case illustrates are: (1) that fibroma of the orbit is not influenced by roentgen ray therapy, (2) that a tumor within the muscular cone moves with the eye and may cause papilledema early in its course and (3) that a nonadherent orbital tumor is easily removed by the transconjunctival route, especially if it is in the lateral half of the orbit.

412 Linwood Avenue.

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21. Reese, A. B.: Orbital Tumors: Part II, Am. J. Ophth. **24**:497 (May) 1941.

22. Dunnington, J. H.: Removal of Orbital Tumors, Arch. Ophth. **22**:510 (Sept.) 1939.

THE CORNEA

III. HYDRATION PROPERTIES OF EXCISED CORNEAL PIECES

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The present investigations on corneal hydration (turgescence and/or deturgescence) were carried out with two objectives in mind: first, to obtain data on the physical-chemical properties of the cornea and, secondly, to clarify further [1] the roles of the various structural components in maintaining corneal function. To accomplish these aims, it seemed best to determine the amount of turgescence of corneal pieces in different solutions and then to consider swelling of the whole cornea under a number of conditions. In the interests of simplicity the present paper will be confined to reporting the findings acquired from studying hydration of corneal pieces, while the results obtained from the use of whole corneas will be published in a following paper.

It has long been known that gross corneal sections possess an enormous swelling capacity. Chevreuil [2] showed that 100 Gm. of cornea would take up 461 cc. of water and 370 cc. of salt water when placed in these fluids. Donders [3] reported sections of partially dried corneas when immersed in distilled water for ten minutes would increase in thickness thirteenfold or fourteenfold as compared with similar sections placed in oil. He also found that after one hour in 0.068 per cent sodium chloride solution the swelling amounted to somewhat less and that small additions of acetic acid would shrink corneas previously allowed to turgesce in distilled water.

From the Howe Laboratory of Ophthalmology, Harvard Medical School.

1. Cogan, D. G., and Kinsey, V. E.: The Cornea: I. Transfer of Water and Sodium Chloride by Osmosis and Diffusion Through the Excised Cornea, Arch. Ophth. **27**:466 (March) 1942; II. Transfer of Water and Sodium Chloride by Hydrostatic Pressure Through the Excised Cornea, Arch. Ophth. **27**:696 (April) 1942.

2. Chevreuil: De l'influence que l'eau exerce sur plusieurs substances azotées solides, Ann. clin. et physiol. **19**:32-60, 1821.

3. Donders, F. C.: Imbibitionserscheinungen der Hornhaut und Sclerotica, Arch. f. Ophth. (pt. 1) **3**:166-176, 1857.

In a paper on corneal morphology, Schweigger-Seidel [4] mentioned that dog corneas would swell in 10 per cent sodium chloride solution but presented no quantitative data. Leber [5] pointed out that an ox cornea in distilled water increased its water content from 78.9 to 94.7 per cent in one day and to 96 per cent in four days. Also, he found the swelling to be the same in the aqueous and in 0.9 or 2 per cent sodium chloride solution. The latter finding, it should be noted, was contrary to Donder's results.

Bullot [6] studied the swelling both of corneal pieces and of the cornea as a whole. Using thickness as a measure of swelling, this author found that rabbit corneas swelled to about 7 times normal (2 mm.) in distilled water. He then measured the swelling in sodium chloride solutions and found that it decreased from 2 mm. in a 0.0001 molar concentration to 1.5 mm. in a 2 times molar concentration. He obtained the same results with potassium chloride, lithium chloride, ammonium chloride, sodium bromide, sodium iodide, sodium fluoride, sodium nitrate, sodium sulfate and sodium carbonate. In calcium chloride, barium chloride, strontium chloride and magnesium chloride the swelling was at a minimum in 0.01 molar concentration and increased with greater or less dilution, but more toward molar concentration. Bullot found the swelling of corneas in cane sugar solution to be the same as in distilled water through a range of concentrations equivalent to 0.1 molar to 1.0 molar.

More recently Fischer [7] found that rabbit corneas placed in distilled water would increase in weight 4.3 times in twenty-four hours, thereby increasing their water content from an initial 76 per cent to about 95.5 per cent. When the corneas were bathed in 0.5 molar concentrations of glycerin, sucrose, urea and dextrose, he reported, the swelling after twenty-four hours amounted to 4.0, 2.4, 3.2 and 6.0 times, respectively. This author also noted various amounts of turgescence and deturgescence when corneas were bathed with acetone and pyridine. In general the corneas would swell in the more dilute solutions of these two substances and shrink in those of approximately 50 per cent concentration.

Fischer also studied the influence of acids and alkalis on corneal swelling, but since he did not determine the p_H of the solutions either

4. Schweigger-Seidel, F.: Ueber die Grundsubstanz und die Zellen der Hornhaut des Auges, Ber. d. Gesellsch. d. Wissensch. zu Leipzig **21**:305-359, 1869.

5. Leber, T.: Cirkulations- und Ernährungsverhältnisse des Auges, in Graefe, A., and Saemisch, E. T.: Handbuch der gesamten Augenheilkunde, ed. 2, Leipzig, Wilhelm Engelmann, 1903, vol. 2, pt. 2, chap. 11, p. 363.

6. Bullot, G.: On the Swelling of Organic Tissues—Researches on the Cornea, Am. J. Physiol. **12**:297-303, 1904.

7. Fischer, F. P.: Ueber die Beschaffenheit der äusseren Bulbushüllen bei abnormen intraokularen Druck, Arch. f. Augenh. **103**:1-75, 1930.

before or after the period of swelling or state the size of the pieces of cornea tested, from which one might calculate the p_H, it is difficult to interpret his results.

In the same paper Fischer stated the order with which various salts depress the corneal swelling in acids and alkalis but failed to take the p_H of the solutions into account.[8]

In comparing the water-binding power of different kinds of connective tissue, Heringa and co-workers [9] allowed cow corneas to come into equilibrium with various partial pressures of water vapor. They found that water absorption isotherms coincide for the cornea and the sclera below 80 per cent saturation of the surrounding atmosphere, but above this value the curves diverge. This divergence was especially marked above 90 per cent saturation, from which point the cornea continued to take up water to 10 times its dry weight. The fact that the cornea is analogous to the umbilical cord in its swelling capacity and mucoprotein content suggested to the authors that the corneal constituent mucoitin–sulfuric acid was responsible for the observed turgescence. On extracting mucoitin–sulfuric acid from the cornea they found that the swelling capacity in 100 per cent saturated water vapor was reduced from 30 times to 13 times the dry weight. They pointed out that the mucoid effect becomes especially large when the vapor pressure of the surroundings reaches about 100 per cent saturation, which is the case under physiologic conditions.

While it is possible to conclude from the literature cited that the cornea will swell varying amounts in salt solutions and in water, the quantitative relations, if any, between swelling, concentration, time, p_H, etc. are lacking. It will be one of the objects of the present paper to supply such data.

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8. The necessity of considering the p_H when evaluating the effect of a salt on swelling in a particular strength acid or alkali has been repeatedly stressed in the literature, especially by Loeb. The influence of the p_H on the results reported by Fischer may best be illustrated by an example. Fischer allowed a piece of cornea to swell in a solution composed of 5 cc. of 0.4 normal hydrochloric acid, 8 cc. of water and 12 cc. of 0.4 molar sodium chloride solution and in a solution containing the same dilution of acid with 12 cc. of 0.4 molar sodium acetate solution. The cornea swelled to 5.2 times its original thickness in the former solution and did not swell at all in the latter. Disregarding the slight increase in p_H in both solutions due to the presence of the cornea itself, we found the p_H to be 2.17 for the sodium chloride solution and 4.80 for the sodium acetate solution. Thus the difference in the degree of swelling may be entirely a p_H effect and have nothing to do with the properties of the salt.

9. Heringa, G. C., and Weidinger, A.: Structure and Importance of Connective Tissue: XI. Water Binding in the Intermediary Substance, Nederl. tijdschr. v. geneesk. **84**:4907-4917, 1940. Leyns, W. F.; Heringa, C., and Weidinger, A.: Water Binding Capacity of Cornea, Acta brev. Neerland. **10**:25-26, 1940.

METHODS

Of the various means available for determining corneal hydration, the weight method was selected as the most accurate and convenient.

A precision torsion balance capable of distinguishing differences of 0.1 mg. and having an absolute accuracy of 0.2 mg. was used throughout this study. Pieces of cat corneas taken from one to three hours after the death of the animals were touched to filter paper to remove excess moisture and weighed within fifteen seconds after withdrawal from the test solution. Usually about seven pieces were obtained from a single cornea. It was therefore possible to make three separate tests in duplicate as well as a determination of the initial moisture for each cornea. The initial weight varied from 10 to 25 mg. and did not appear to influence the rate or the extent of the swelling. The corneal pieces were then immersed in stoppered vials, which usually contained 4 cc. of the test fluid. All experiments were carried out at room temperature, which varied from 21 to 26 degrees centigrade from winter through summer and probably less than 3 degrees centigrade in a single experiment. The corneal samples were withdrawn at intervals and reweighed after removal of the excess moisture.

All p_H determinations were made electrometrically.

Some experiments were undertaken to determine the mechanical pressure necessary to prevent swelling:

Small brass cylinders 2.5 cm. in diameter and 2.5 cm. high were bored half way through to make a 1 cm. hole. From the other side a 7 mm. hole was bored to join with the first hole. In the offset formed in the middle was placed a porous alundun disk. Sections of cornea were then cut with a cork borer of a size which would just cover the filter disk, and on top of this were placed brass weights of appropriate magnitude. The cylinders were then immersed in the solutions to be tested. In practice it was found that the cornea was completely surrounded by the test fluid. All calculations were made on the basis of an initial moisture content of the cornea of 78 per cent.

From the preceding survey of the literature it will be recalled that variations in the state of corneal turgescence may be presented in several ways. The three most prevalent methods have been: first, use of percentage of the moisture content; secondly, use of percentage increase from the dry weight, and, thirdly, use of percentage of the initial weight. The chief disadvantage of the first method is that as the cornea swells the moisture content approaches asymptotically 100 per cent as a limit, and the figures expressed are difficult to interpret in terms of actual changes in weight. For example, should a cornea increase its water content 16.5 per cent (say from a normal initial value of 78 per cent to 94.5 per cent) it would have but quadrupled in weight, whereas if it increased 20 per cent it would have increased to eleven times the original weight. The second method, while accurate, results in the absolute magnitude of the swelling of corneal tissue; and, although this properly emphasizes

the fact that all normal corneas are already partially hydrated, the use of the dry weight as a reference point is somewhat foreign to thinking in physiologic terms. For the present purposes the third method, that of expressing the result as percentage of the initial weight, appears to show best the degree of corneal turgescence and deturgescence. An example of how corneal hydration is calculated by this method is as follows: If in 2 cases the initial weight is 20 mg. and the final weight is 16 and 36 mg., the cornea is said to be swollen 80 per cent and 180 per cent, respectively. In the charts the ordinates are calculated in this manner and are labeled "swelling in per cent."

It should be noted that when the cornea loses water the percentage swelling does not fall quite proportionately, because of the solid matter present. Thus, if a cornea had shrunk to half its initial weight the swelling would be reported as 50 per cent, but the water loss would be approximately 64 per cent. Since few corneal pieces having appreciably less than the initial water content were encountered, this fact need not be considered further.

As mentioned before, the original state of hydration was determined on a sample from each cornea to insure that undue drying had not preceded the initial weight determinations on the test samples. This was necessary because the final state of hydration is not appreciably dependent on the initial state, and spurious percentage swellings would have resulted had dried-out corneas been used. Even with the aforementioned precautions being taken and a variation in the initial water content of but 3 per cent being considered within normal limits (75 per cent to 78 per cent moisture), the error introduced by use of an initial moisture content of 75 per cent instead of 78 per cent would amount to one eighth of the reported percentage swelling in distilled water. Such inherent variations in the extent of turgescence invalidate the ascribing of any significance to small observable differences.

RESULTS

Chart 1 shows the amount of swelling of corneal pieces when immersed in sodium chloride solutions of varying concentrations for two arbitrarily selected time periods (1,200 and 10,000 minutes). It will be seen from the 1,200 minute curve, each point of which is an average of 6 experiments, that increasing the sodium chloride concentration up to about 1 per cent decreases the amount of swelling, but further increases in the concentration of the salt have little or no effect on the extent of swelling. From the 10,000 minute curve, however, the reverse effect of concentration is observable up to about 1 per cent; thereafter there appears to be a significant decrease in turgescence with an increase in

the salt concentration. Each point on the 10,000 minute curve is an average of 2 experiments.

Chart 2 illustrates the rate of swelling of corneal pieces in several selected concentrations of sodium chloride. The results represent experiments not shown in chart 1, excepting the distilled water curve, which is an average of 7 experiments. Each point on the graph is made up of an average of 2 experiments. From the curves it will be seen that swelling occurs much more rapidly in distilled water than in the sodium chloride solutions. Moreover, the swelling in distilled water reaches a

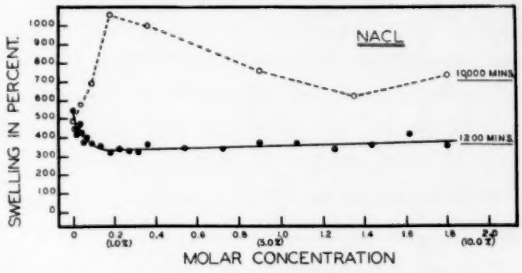

Chart 1.—The average percentage swelling of corneal pieces in various concentrations of sodium chloride solution for two time periods.

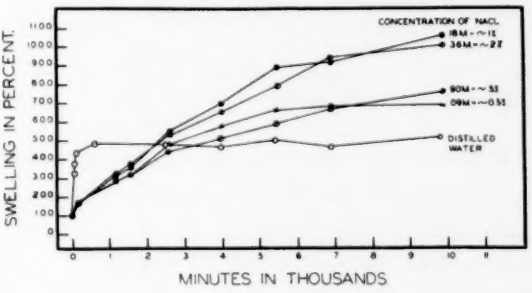

Chart 2.—The average rate of swelling of corneal pieces in various concentrations of sodium chloride solution.

maximum within approximately 500 minutes, whereas the swelling in the salt solutions continues throughout the whole of the 10,000 minute observation period.

The results shown in charts 1 and 2 clearly demonstrate the inadequacy of making a comparison of the degree of swelling in various concentrations of a salt without taking into account variations with time. This is best illustrated in chart 2 by comparing the amount of corneal swelling in distilled water with that in the salt solutions. It will be seen that the swelling in the water is greater than in any of the sodium

chloride solutions up to about 2,200 minutes, but after 3,200 minutes the turgescence in all the sodium chloride solutions shown is greater than in distilled water.

Chart 3, in which each point is an average of 2 experiments, shows that the amount of swelling when corneal pieces are immersed in various glycerin, urea and dextrose solutions for 1,050 minutes is not appreciably affected by the concentration from distilled water to 1.9 molar. No graph is presented to show the rate of swelling, since it, too, appears to be indistinguishable from that in distilled water; this has already been shown (chart 2). Many additional experiments were performed with dextrose for longer periods of time than that shown in chart 3, but the results were inconclusive because the solutions became acid.

Corneal swelling in a series of salt solutions was determined in an attempt to relate it to particular elements or radicals or possibly to some common property of these elements, such as valence. All the salts selected form neutral solutions in distilled water. The findings of over

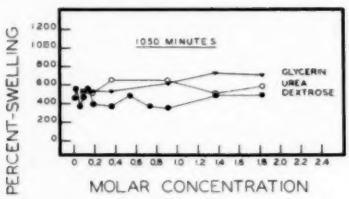

Chart 3.—The average percentage swelling of corneal pieces in various concentrations of glycerin, urea and dextrose for one time period.

two thousand measurements are summarized in charts 4 and 5. In chart 4 swelling is plotted as a function of concentration for the time intervals 1,200 and 9,000 minutes, and in chart 5 the rate of swelling is shown for a particular concentration (0.19 molar). The 1,200 minute series represents an average for 4 pieces per point and the 9,000 minute series an average for 2 pieces.

Chart 4 also well illustrates the need for stating both the time and the concentration before generalizing about the relative amount of corneal swelling in solutions of any two compounds. For example, in the lower section it may be seen that the cornea swells less in 1,200 minutes in lithium chloride solution up to approximately molar concentration than it does in potassium chloride solution in the same time; but in higher concentrations the reverse is true. On the other hand, after 9,000 minutes the cornea swells more in potassium chloride solution up to molar concentration than it does in lithium chloride solution. Again

there is a reversal above molar concentration. Thus, by properly, if arbitrarily, selecting the time and the concentration, one could arrange the salts in almost any order with respect to their influence on corneal turgescence.

Chart 4 also shows that, of the five chlorides tested, the swelling in only lithium chloride and magnesium chloride increased with the concentration up to 2 times molar, and of these only the former did so both at 1,200 and at 9,000 minutes. (The overlapping at 1.8 molar concentration of the magnesium chloride curves for 1,200 and 9,000 minutes is caused by experimental variation in the two sets of

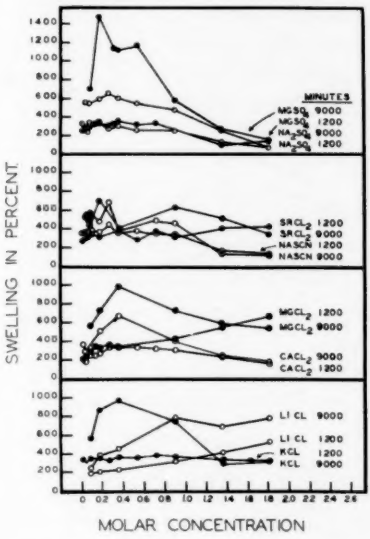

Chart 4.—The average percentage swelling of corneal pieces in various concentrations of different salts for two time periods.

determinations.) The remaining chlorides (strontium, calcium and potassium) appear to have little in common. Similarly, there is no apparent relation between corneal swelling and the particular cation or the valence of the anions or cations. The swelling in each case seems to be characteristic for the particular salt, concentration and time.

Because of individual variations small differences in swelling or isolated aberrations, such as the peak at 0.30 molar in the 9,000 minute sodium sulfocyanate curve, are not significant. On the other hand, such general trends as that shown by the increase in swelling from 0 to 0.35 molar in the 1,200 minute calcium chloride curve are no doubt significant.

Chart 5 shows that, with the exception of lithium chloride and perhaps sodium sulfocyanate, corneal swelling in all the 0.19 molar solutions tested proceeds at least for 10,000 minutes. Even for this one particular concentration there is no apparent relation between the amount of swelling and any chemical property of the salts.

The results showing the effect of p_H on corneal swelling are shown in chart 6. Each point represented by a solid circle is an average of 6 determinations. The open circles refer to the acetic acid solutions only

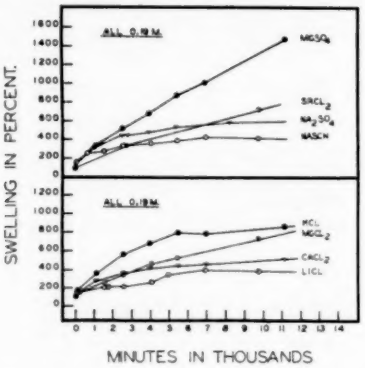

Chart 5.—The average rate of swelling of corneal pieces in different salt solutions of the same molality.

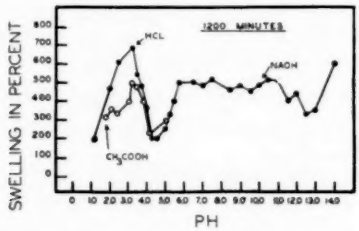

Chart 6.—The average percentage swelling of corneal pieces at different hydrogen iron concentrations in hydrochloric acid and sodium hydroxide (solid circles) and in acetic acid (open circles) for one time period.

and represent duplicate experiments. Since the p_H of the solutions tended to approach neutrality as a result of the buffering action of the cornea itself, only final p_H values were plotted. Moreover, only by chance were two solutions at exactly the same p_H at the end of the 1,200 minute test period. This made it necessary to use the method of sliding averages to obtain one curve truly representative of the 6 separate experiments. The experimental variation between duplicates was greatest in

the alkaline range. From the curve made up of solid circles it may be seen that the swelling is almost constant from p_H 6 to about 11; beyond this there is a slight decrease in swelling. The increased swelling after 1,200 minutes at p_H 14.0 preceded dissolution, which appeared to be complete about 800 minutes later. The iscelectric point of the cornea as determined by minimum turgescence is seen to be about p_H 4.3. At the higher hydrogen ion concentrations the swelling obviously increases to a maximum at 3.5 and thereafter again decreases. The curve made up of open circles represents similar experiments with acetic in place of hydrochloric acid. The general shapes of the curves are seen to be the same, but the degree of swelling is considerably less for acetic acid between p_H 2.0 and 3.4 for the 1,200 minutes. The apparent isoelectric point is also seen to be the same. Whether additional swelling would have occurred if longer periods of time had been taken was not determined. It is sufficient to point out that the effect of p_H alone on swelling is no doubt

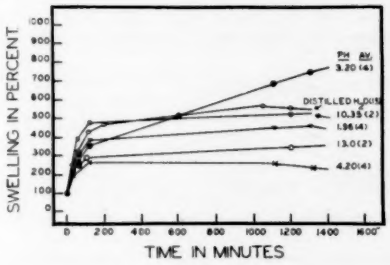

Chart 7.—The average rate of swelling of corneal pieces in distilled water and in solutions of various hydrogen ion concentrations.

always complicated by the presence of the anion, i. e. acetate and chloride in these experiments.

Chart 7 shows the rate of swelling at six separate p_H values. From the solid circle curve of chart 6 it will be seen that the places selected correspond to the peaks and valleys of this curve. The rate curves show that approximately maximum swelling has taken place within the first 200 or 300 minutes except at p_H 3.2. The rate in the curve for this p_H corresponds in general to that for the swelling in salt solutions, in that the swelling continues for a longer period. Similar observations on the rate of swelling at other p_H values between 2.35 and 4.05 (not shown in chart 7) showed that swelling continued throughout the 1,200 minute period of observation. No explanation of this phenomenon is apparent.

Charts 8, 9 and 10 illustrate the effect of various mechanical pressures on corneal swelling. The dotted line represents the total solids

of the cornea in every case. From chart 8 it may be seen that corneal swelling in distilled water is decreased progressively by higher pressures. The normal state of corneal hydration appears to be maintained in distilled water by a pressure of approximately 140 Gm. per square centimeter. It may be seen that higher pressures deturgesce the cornea.

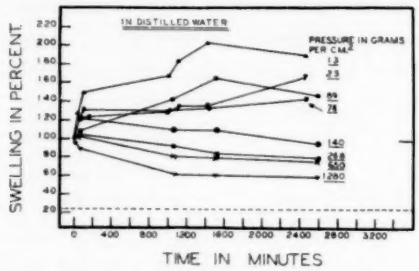

Chart 8.—The average rate of swelling of corneal disks in distilled water when opposed by various mechanical pressures.

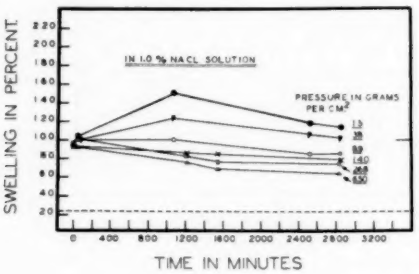

Chart 9.—The average rate of swelling of corneal disks in 1 per cent sodium chloride solution when opposed by various mechanical pressures.

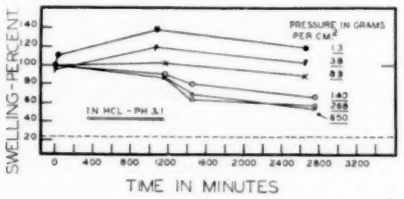

Chart 10.—The average rate of swelling of corneal disks in a solution of hydrochloric acid (p_H 3.1) when opposed by various mechanical pressures.

It would appear that in 1 per cent sodium chloride solution (chart 9) less pressure is required to prevent corneal swelling; e. g. about 40 Gm. per square centimeter is just sufficient to maintain normal hydration. Similar results were found with hydrochloric acid at p_H 3.1 (chart 10).

COMMENT

The fact that the degree of swelling throughout a wide range of concentrations of dextrose, urea and glycerin (chart 3) is indistinguishable from that in distilled water shows that the swelling is not dependent on the osmotic pressure per se of the solutions. The apparent independence of corneal swelling and the concentration of the different salt solutions shows that this conclusion is also valid for salt solutions. This suggests that both the nonelectrolyte and the electrolyte molecules tested are too small to cause an osmotic pressure difference between the corneal micellae and the solution. It does not mean that no osmotic pressure difference exists between the inside and the outside of the corneal micellae, since presumably the protein or polysaccharide molecules of the micellae themselves would be sufficiently large to create a difference in osmotic pressure. For example, Kunitz [10] has observed that the swelling of isoelectric gelatin in salt solutions is an osmotic phenomenon but that the increase in osmotic pressure is due not to the ions of the salt but to an increase in the osmotic pressure of the proteins when surrounded by such ions. Part of the swelling noted for gelatin resulted from a decrease in the elasticity of the gel with a concomitant reduction in the resistance of the gel to swelling.

It would appear noteworthy that the solutions of nonelectrolytes tested have the same effect on corneal swelling as does distilled water. On the other hand, salt solutions produce a difference in swelling, affecting both the amount and the rate.

The amount of pressure required to prevent the cornea from swelling in 1 per cent sodium chloride solution is of the order of 30 mm. of mercury. In the experiments the pressure was applied as a squeeze, so that the efficiency with respect to prevention of imbibition was probably rather high and is not immediately applicable to physiologic conditions. More experimental evidence concerning the relative role of the intraocular pressure in keeping the cornea at a normal level of hydration will be presented at a later time.

In conclusion emphasis should be placed on the fact that the normal cornea swells in practically every aqueous solution in which it has been placed. The conditions under which the cornea, although surrounded by similar aqueous solutions, does not swell will be presented in the next paper of this series.

10. Kunitz, M.: Elasticity, Double Refraction and Swelling of Isoelectric Gelatin, J. Gen. Physiol. **13**:565-606, 1930.

SUMMARY AND CONCLUSIONS

Measurements have been made to determine the amount of swelling of pieces of cat corneas in:

1. Various salt solutions from 0 to 2 times molar concentration for periods up to 10,000 minutes.

2. Various nonelectrolyte solutions from 0 to 2 times molar concentration for 1,050 minutes.

3. Solutions of various hydrogen ion concentrations (p_H 1.0 to 14.0).

4. Distilled water, 1 per cent salt solution and hydrochloric acid (p_H 3.1) when subjected to various mechanical pressures (13 to 1,280 grams) per square centimeter.

Pieces of cat corneas were found to swell in practically all the aqueous solutions tested. The degree of swelling could not be correlated with osmotic pressure of the solutions, valence of the electrolytes or nature of the ions. Each salt appeared to have a specific effect on the rate and the degree of corneal turgescence. Solutions of nonelectrolytes have the same effect on corneal turgescence as does distilled water. The isoelectric point as determined by the minimum amount of swelling was found to lie at p_H 4.3. Normal corneal hydration was just maintained by a mechanical pressure of approximately 140 Gm. per square centimeter in distilled water and 40 Gm. per square centimeter in both 1 per cent sodium chloride solution and hydrochloric acid having a p_H of 3.1.

Miss Cynthia Steitz and Miss Sally Walker assisted in performing the experiments reported.

OBSERVATIONS ON ENTOPTIC PHENOMENA

BENJAMIN FRIEDMAN, M.D.
NEW YORK

Strictly speaking, entoptic phenomena are concerned with the auto-visualization of certain structures within the eye through the propitious arrangement of incident light. These structures may be normal to the eye or they may be pathologic imperfections, such as opacities in the vitreous or lenticular flaws. Pressure and traction on the retina and the optic nerve may cause subjective awareness of these structures by evoking from their highly differentiated pathways various sensations resembling those induced by light: There must be included under the heading of entoptic, therefore, a number of phenomena which result from these nonspecific (inadequate) stimuli. The general subject has been covered thoroughly in the works of von Helmholtz, Duke-Elder and Adler and in the recent "Traité d'ophtalmologie." It is the purpose of this paper to dwell chiefly on several observations and explanations which are wholly or in part original in character. The data have been accumulated during the past twelve years. It is hoped that sufficient interest will be stimulated to prompt further work by other investigators.

OPACITIES IN THE OCULAR MEDIA

One knows that the ocular media, with the exception of the aqueous, by the nature of their cellular structure and their irregular refractive indexes, are not perfectly transparent, yet under ordinary circumstances one is unaware of their imperfections. Indeed, patients are often oblivious to even very large opacities. The optical conditions involved in the subjective perception of opacities in the cornea and in the lens of the eye may be reproduced simply: An L-shaped piece of adhesive tape is stuck to the surface of a condensing lens, and the image of a light source is brought to a focus on a white paper. If the focus is perfect the opaque artefact cannot be discerned in the image. But if the lens is "defocused" by moving the paper forward or backward the opacity reveals itself by an upright or an inverted shadow.

In figure 1 O is one point in a light source (OO') which passes through the condensing lens and is imaged at I. An opacity, AB, on the lens casts its cone of shadow toward I. O, however, is reproduced at I by the remaining unintercepted rays such as OL (not drawn), which

strike the clear lens surface, and the effect is a sharp image at I, but an image less brilliant because it is minus the rays which would normally pass through the lens at AB. Any other point on the object may be similarly treated.

It is for this reason that an opacity in the cornea or in the lens is not defined on the retina under natural conditions; nor can it be outlined as a scotoma against the tangent screen. The incident rays from the test object will follow similar paths, and there will be no point on the tangent screen which will not be imaged on the retina; all the images from the various positions on the tangent screen will be of equal intensity.

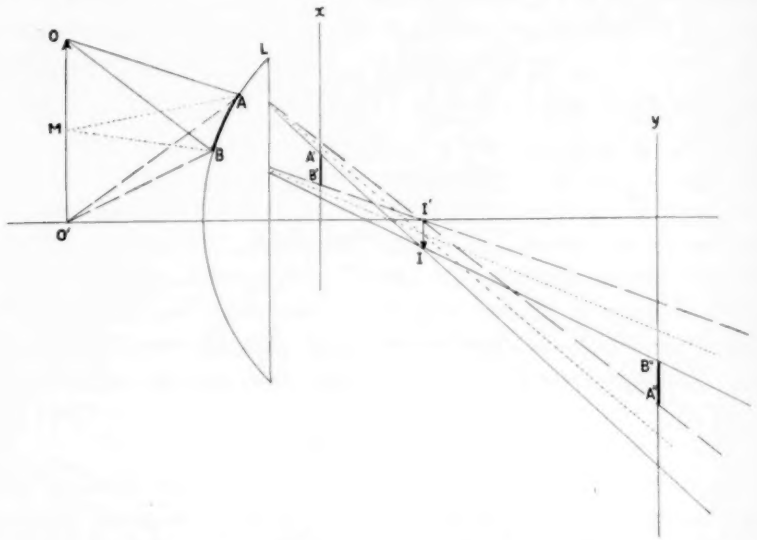

Fig. 1.—The paths of the shadows cast by an opacity (AB). The shadows do not interfere with the formation of the image at the focal plane, since other rays, such as OL (not drawn), serve to form a complete and shadowless image. The cones of shadow may be intercepted at x to form an upright shadow or at y to form an inverted shadow.

Each point on OO' will cast its respective cone of shadow, for example M and O'. It will be seen that a card held anterior to the image plane at x will receive no rays at $A'B'$ (the umbra) and will reveal an upright shadow. $A'B'$ is the area common to all the shadow cones. It is larger as the lens is approached; it ceases to exist when the shadow cones fail to provide mutual coverage.

One can make the eye entoptically conscious of many of its structural details by defocusing it along the same principles through the intervention of strong minus or plus lenses placed in front of the cornea.

When a strong minus lens is held between the eye and a light source the ocular focus is thrown far behind the retina (as in position x). The shadow of a corneal or lenticular opacity will fall on the retina as an upright defect in the image, but it will be interpreted by the brain as an inverted shadow.

If the card is shifted behind the focus of the lens to y, the shadow of AB will be inverted, larger and less intense ($B''A''$).

If the eye is defocused by means of a strong plus lens, the retina lies behind the focus (as at y) and a corneal or lenticular opacity will fall on the retina as an inverted shadow, but it will appear to be upright.

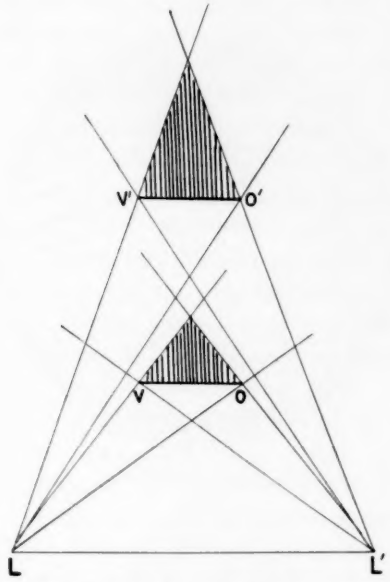

Fig. 2.—The lengths of shadows cast by opacities of equal size but unequally distant from the light source.

The strongly ametropic eye (uncorrected) tends to be self adapted for this phenomenon, but it is seldom sufficiently ametropic to cause the umbra of a corneal or lenticular opacity to fall on the retina; the opacity is too far forward. Even if the retina were in position to receive the umbra it would probably be unnoticed in the general blur which the ametropia would provide. The larger the corneal or lenticular opacity, the broader and longer will be its umbral cone.

But emmetropic patients, even under normal optical conditions, when there is no defocusing of rays, are often distressingly aware of an opacity in the ocular media. Their awareness occurs when the opacity lies in the vitreous and not when it lies in the lens or in the cornea. The size of

the opacity and its distance from the retina are the factors which determine the position of the umbra in respect to the retina (fig. 2).

Let *LL'* represent the light passing through the pupillary plane and *VO* an opacity in the vitreous. *V'O'* is an opacity of the same size but closer to the retina; its umbral cone will be larger in direct proportion to its backward displacement. The farther back the location of an opacity in the vitreous, the greater the probability that its umbra will fall on the retina. The diameter of the conic section falling on the retina will be directly proportionate to the backward displacement of the particular opacity.

At a given location, the larger the opacity, the longer and broader will be its umbra. On the other hand, a small opacity close to the retina may cause a larger section of its umbral cone to impinge on the retina than that of an extensive opacity which happens to lie farther forward. An opacity which casts a sharp umbra on the retina may be outlined as a positive scotoma against an evenly white background. The uniformity of the background provides no distracting details which might interfere with the recognition of the shadow.

If an opacity lies well forward in the vitreous it will have to be relatively large to disturb the retina by its umbra; a small opacity at the same level will cast its umbral cone far in front of the retina and cause little or no annoyance. The closer the opacity lies to the plane of the retina, the less evident is the penumbra and the larger and more sharply defined the umbra. One may readily illustrate this fact by holding a pencil between a light source and a white paper; the closer the pencil is held to the paper the larger and more clearly defined is the umbra and the less evident is the penumbra. There is much greater contrast between the dark shadow and the rest of the receiving surface when the umbra is at its maximum and the penumbra at its minimum. This statement applies to the retina, and it explains the extreme annoyance caused by even a very small opacity which lies near the retina and the indifference to a much larger opacity which happens to be situated anteriorly.

THE CORNEA

The cornea is the seat of a number of interesting entoptic manifestations. In studying these phenomena I found it best to employ a light source which is small and bright. A lighted candle or muscle light placed in a darkened room at a distance of about 10 feet (300 cm.) is excellent, but better still is the light from the naked bulb of an electric ophthalmoscope. The light is viewed through a scrupulously cleaned + 20 D. lens which is held about 1 to 2 cm. from the eye. The entoptic field is bounded by the circular border of the pupil.

Folds in the Corneal Epithelium.—(*a*) Superficial: George Bull [1] has gone into considerable detail in respect to superficial pressure lines, and he described the appearance of horizontal bands after the maintenance of the lids in a half closed position for a minute or more. He stated that they appear as one or two bright horizontal bands with dark borders and are obviously horizontal folds involving the corneal epithelium.

I am able to visualize as many as six or eight horizontal bands in the entoptic field at one time. They run in an unbroken line across the entire width of the pupil. They change their positions as the lids are slowly approximated or separated, advancing as the lids advance and

Fig. 3.—Entoptic appearance of superficial corneal folds.

receding slightly as the lids recede. Those formed by the pressure of the lower lid are usually straight, while those caused by the upper lid, especially the nearest ones, exhibit a slight bowing, with the convexity upward, following the curvature of the upper lid margin. The folds seem superficial and disappear in a few moments. They must not be confused with the entoptic image of the tear level.

Bull stated the belief that these folds are a source of annoyance to artists, microscopists, persons who read in bed and other persons who have developed a habit of keeping one eye closed or partially closed. He recorded that after he had used the ophthalmometer for a portion of the day the eye which he kept closed had vertical diplopia and reduced vision on being opened for the conduct of other tasks, and he coined the term "tarsal asthenopia" to indicate the guilt of tarsal pressure. One is often made aware of such pressure effects on the vision in clinical prac-

1. Bull, G.: Tr. Eighth Internat. Ophth. Cong., Edinburgh, 1894, p. 107.

tice when a patient has subjected one eye to pressure from his fingers while closing it during the process of taking the field or testing the sight of the other eye.

(*b*) Deep: I have produced folds in exaggerated form objectively in the eyes of patients undergoing diathermy treatment. The electrode was covered with a towel and was held against the eye for periods of fifteen minutes. It was readily possible to see the folds by focal illumination and to study their change of form and position as they responded to the pressure of my fingers through the partly opened lids. They were also seen well by means of the plane retinoscope or the ophthalmoscope with a + 20 D. lens set in the aperture. The normal reflection from the anterior corneal surface appeared irregularly broken

Fig. 4.—The "irregularities of the corneal surface" produced by rubbing (after Bull [1]).

up by the folds. Vision under these conditions was seriously interfered with, the visual acuity generally dropping from 20/20 to 20/40.

A Verhoeff astigmatic chart with a + 20 D. lens behind a central opening, after the manner of a Placido disk, may be employed for study of the irregularities of the corneal reflexes; the distortion produced by the horizontal folds can thus be noted. The pressure and the warmth cause a great increase in the number of fatty particles present in the extraocular fluid, and these are annoying to the observer; it is difficult to remove them even by flushing the conjunctival fornices with saline solution.

The folds induced by prolonged pressure persist for an hour or more, and they appear to extend through the entire thickness of the epithelium. This is not surprising when one recalls how easily the epithelial layer is displaced while one is removing a foreign body from the cornea. The

depth of the folds may be crudely estimated by moving the focused ophthalmoscope forward and backward until the folds are thrown out of the focal limits. The folds are seen only vaguely with the slit lamp. I find that the entoptic observation of these deep folds in my own eyes is not nearly as satisfactory as their objective examination in the patient's eye by means of the ophthalmoscope or focal illumination. The superficial folds, on the contrary, are easy to see entoptically.

The path of a fat corpuscle can be traced over the cornea with the ophthalmoscope. It is usually uninterrupted by the folds because the tears fill in the irregularities of the surface, allowing the fat corpuscle to float evenly along.

Bull also described the entoptic appearance of "tigered or net like markings produced by applying pressure to the cornea through the lids" and was "satisfied that they indicate irregularities of curvature of the epithelial surface, probably due in fact to a wrinkling of the corneal epithelium."

Von Helmholtz [2] made note of somewhat similar "irregularities on the anterior surface of the cornea after pressing or rubbing the closed eye for a time with the fingers." These are easily distinguished from mucus or other adventitious substances which might happen to lie in front of the cornea.

Channels in the Corneal Stroma.—These are best studied by focusing the light from a distant candle or bare ophthalmoscope bulb into the eye with a 6 × loupe, although a + 20 D. lens is fairly satisfactory. For greater magnification a 10 × loupe may be employed. With this optical system rays which strike an opacity in the eye will impinge on it in varying degrees of convergence or divergence, depending on whether the opacity lies in front of or behind the new artificial posterior focus of the eye. Its size will be considerably magnified, and this method discloses several phenomena which are in no other way adequately discernible (fig. 5 *A*).

When the ophthalmoscope light is viewed through a 6× magnifying loupe and the lids are vigorously blinked several times a remarkable picture comes into view. The pupil becomes traversed by a number of vertical double parallel lines which take on the appearance of channels through the cornea. One is immediately impressed by their relatively fixed station. They may move slightly in a horizontal direction under the pressure of the lids. In some places they communicate with their neighbors by short connecting channels, or they may bifurcate. They are

2. von Helmholtz, H.: Helmholtz' Treatise on Physiological Optics, translated from the third German edition, edited by J. P. C. Southall, Ithaca, N. Y., The Optical Society of America, 1924, vol. 1, p. 207.

quite different in appearance from the horizontal pressure lines previously described. The latter may be produced simultaneously for comparison. The vertical double lines are clearcut when properly seen; at times their outlines appear doubly refractile in part of their course. More vigorous blinking brings out channels unnoted before. Suddenly opening the unused eye and transferring the loupe to a position before it will reveal the channels with astonishing distinctness. Squeezing the lids tightly together for several seconds will bring out numerous communicating pathways. The vertical lines lie in closely parallel pairs, with a relatively wide interval between each pair. The channel between the double lines is bright and clear, suggesting fluid content, while the interspaces between the channels are darker and unevenly granular. The vertical lines are not exactly straight but present gentle curvatures in some spots; in other regions the bending is more sharply angular. The individual channels are

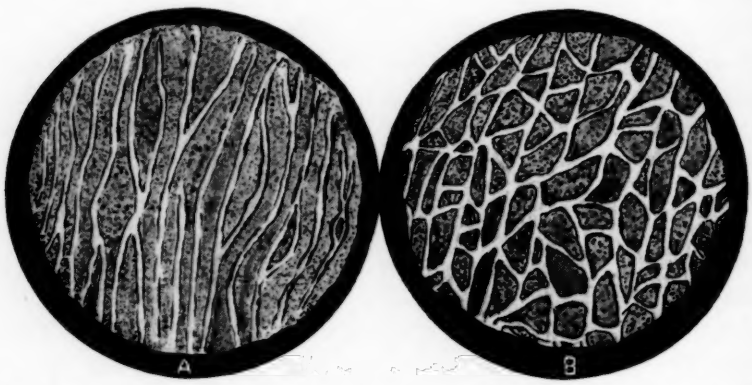

Fig. 5.—*A*, entoptic appearance of vertical corneal channels. *B*, entoptic appearance of communicating vertical, horizontal and oblique channels.

soon recognized and remembered by the peculiarities of their shape, and it will be noted that the same configurations are resumed during the course of the experiment or even in successive experiments on different days. This fact speaks for a definite anatomic structure as being the source of the phenomenon. The channels are not perfectly upright; those in my right eye slant at about axis 105 degrees and those in the left eye at about 75 degrees.

If the cornea is rubbed in a horizontal direction new channels are brought out, and they will course in a predominantly horizontal direction. If the cornea is rubbed in an irregular manner, the entoptic field becomes transformed into a latticework of connecting channels which run in all directions (fig. 6). The lumens of adjacent channels rarely fail to communicate with one another.

The horizontal channels fade away after several seconds, and the vertical soon follow, but they are revived by blinking the lids or rubbing the eye. The vertical channels are the more readily restored.

It is possible to gage their position as lying just behind the tear corpuscles and in front of the strands of vitreous, which are easily recognizable (see appendix). The channels are not depressions or wrinkles in the cornea which might have been produced by the uneveness of the ocular surface of the lids. If they were, the track of a lid irregularity in its passage over the cornea would be a perfectly straight vertical line, and the irregular rubbing of the cornea through the lids would not produce such well defined collaterals in regular positions.

The channels appear to be limited to one stratum of the cornea, seemingly at a deep level. This is evidenced by the fact that there are no underlying or overlying canals to be seen, no matter how the position

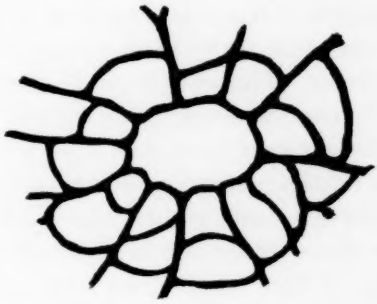

Fig. 6.—Entoptic appearance of perimacular retinal arterioles during pulsation. A drawing gives an unsatisfactory impression, since the picture is not static but changeable at every moment and in every part.

of the loupe is altered. One has the impression that the channels rest on Descemet's membrane, which acts as a backstop.

It is probable that these are channels through which the corneal fluids pass. They cannot possess differentiated walls, since such structures are not seen in histologic sections. They seem to be merely passageways in the parenchymal syncytium which may be visualized under favorable entoptic conditions. Vigorous blinking of the lids seemingly forces the corneal fluid through the channels and renders them more patent and therefore obvious. The channels are best seen vertically, probably because the continuous "milking action" of the lids in winking during the day predisposes to a vertical flow of the fluid, and the extra pressure from the forced blinking simply accentuates the vertical pathways. If pressure is applied to the cornea in other directions, the corneal fluid, as has been seen, opens communicating horizontal and oblique avenues.

It should be borne in mind that the area of the cornea which is normally accessible to entoptic investigation is limited to the part just in front of the pupil. The pupil under the circumstances of the experiment contracts to about 2 mm. in diameter. I can ordinarily count about fifteen to twenty vertical channels in my entoptic field. Alteration of the size of the pupil by homatropine or pilocarpine increases or diminishes the number of visible channels. Mydriasis or myosis makes the details in the entopic field less conspicuous but does not abolish the channels.

The channels may be induced in a patient's eye by rubbing the cornea through the lid; they may be observed objectively by focusing the ophthalmoscope, set with a + 20 D. lens in the aperture, on the dilated pupil. In the patient they are best seen peripherally rather than centrally. Details are poorly seen by this method as compared with the subjective method, but they are recognizable. The slit lamp is of no use for this purpose. The tear corpuscles may be localized on the surface of the cornea, and the difference in the focal levels of the corpuscles and of the corneal channels clearly indicates that the channels lie well within the corneal stroma. They soon become lost when the focus of the instrument is directed backward toward the lens, this fact furnishing an additional proof of their corneal location.

If one compares the picture of the corneal channels seen after rubbing the cornea with figure 4, a striking similarity is noted. It is my belief that the netlike appearance of the cornea described by Bull was caused by the structures which I have called the intracorneal channels, that these structures were misinterpreted as irregularities in the corneal epithelium. I have not been able to duplicate such markings in the epithelium proper.

The corneal channels are seen readily, often even without blinking or rubbing, when the plus lens is held 10 to 20 cm. from the eye. The rays striking the eye will have crossed in front of the cornea, and the image is the reverse of the image which is seen when the lens is held close to the eye. A similar condition may be obtained by holding a strong concave lens at a distance from the eye; moving the lens closer improves the clarity of the picture. Magnification is much smaller and details of the structures are much less evident in both these instances than when the condensing lens is held close to the eye, that is when the cornea lies between the condensing lens and its posterior focal point.

PULSATIONS OF THE RETINAL VESSELS

The pulsations of the retinal vessels can be seen entoptically after physical exercise. Brief and simple statements of this fact are to be

found in the now obscure works of Landois [3] and Jago.[4] Purkinje [4a] had previously described "flicker roses" which were visible in the central field after exertion and after the taking of digitalis. The rosette figures appeared and disappeared with a wavelike motion.

If the gaze is directed toward an expanse of bright cloudless sky immediately after violent exertion, a dark pattern of rapidly moving figures is to be seen against the uniform background. The eyes should be kept quiet and should stare vacantly for some moments into the space selected. Covering one eye facilitates recognition of the phenomenon.

It must be understood that pulsation of the retinal vessels refers to the actual wave of expansion which at systole passes from the aorta along the arterial tree down to the retinal arterioles. The rate of its propagation is rapid. This wave is not synonymous or synchronous with the passage of the blood along the arterial tree; the rate of flow of the blood is much slower. Entoptic evidence of the flow of blood in the retinal vessels is to be found in the bright, scintillating dots which are readily seen against the sky; these motions are described as pulsatory, but this term merely indicates a pulsatory flow of blood within the vessel and not an expansion wave of the vessel wall.

One notices a rapidly changing, irregular pattern of dark, curved lines or sinuses all interconnected and occupying the middle portion of the visual field. It is soon evident that the changes are due to expansions and contractions of the network, the linear elements of which are recognized as the delineations of the retinal vessels in the paracentral area, greatly magnified. The calibers of these outlines are certainly many times the normal breadth of vessels seen close to the macula in the ordinary entoptic images. The most striking feature is the rapid, never ceasing change in the figure, a change, however, that is regular in its repetition both as to rate and as to pattern. The pattern is visible over an area beginning at the 10 degree circle and extending inward as far as the 2 or 3 degree circle. The very central part of the field, which corresponds to the macular area, is singularly clear and free from the pulsating shadows.

Two phases of the entoptic pulsations are distinguishable. The first is a sharp and rapid expansion of the part of the arterial tree involved, synchronous with cardiac systole. This is followed immediately by the

3. Landois, L.: Textbook of Human Physiology, English translation from the 7th German edition, Philadelphia, P. Blakiston's Son & Co., 1892, p. 134.

4. Jago, J.: Entoptics, with Its Uses in Physiology and Medicine, London, J. Churchill & Son, 1864, p. 128.

4a. Purkinje, J.: Beobachtungen und Versuche zur Physiologie der Sinne, Prague, J. G. Calve, 1823, vol. 1, sect. 23, p. 42. Hanzlik, P. J.: Jan Evangelista Purkyní (Purkinje) on Disturbances of Vision by Digitalis One Hundred Years Ago, J. A. M. A. **84**:2024 (June 27) 1925.

second phase, which is a slower, contractile movement along the same path; it begins at the 10 degree zone and sweeps toward the macula in the form of an advancing wave of contraction. Because of its longer duration, the second phase is the more prominent.

The expansion is momentary, and difficulty is experienced in following its passage, but the contraction path is relatively easy to observe. As the head of the contraction wave travels toward the macula it leaves in its wake a short strip of vessel which remains in view. But the visibility of the trail does not endure long, and before the wave head has had time to reach its destination at the macular border, the trail at the peripheral zone has begun to disappear. Thus, when the inner part of the figure becomes visible the outer part is blank, but by the time the central part of the figure has disappeared the expansion again begins at the 10 degree zone. There is really no appreciable time interval between the disappearance of the wave centrally and the inception of a new wave at the periphery. The first impression is of a series of shifting pulsations which are several times more frequent than the cardiac beat.

When the physical exertion has been unusually strenuous the expansile phase may be observed in the broader portions of the arterial tree, that is, in the more peripheral part of the visual field. The shadowy patterns of nearly the entire arterial tree are momentarily made visible with each heart beat. The vessels dilate with a shock all at once along their entire visible length; they contract almost immediately and disappear from view. The figure appears and vanishes without any suggestion of a wave motion peripheral to the 10 degree zone. The patterns are dark, but the outlines are rather blurred; they extend almost to the region of the blindspot. The duration of visibility is only a small part of a second. The figures in this region are easier to identify with the retinal vessels than those which are more centrally placed.

Considerable practice is required to analyze these components, for the images are seen by the perimacular and peripheral portion of the retina and not by the critical macula, and involuntary attempts to turn central fixation on them simply make them more elusive. The migratory character of the patterns adds to the difficulty. The rapidity of the heart beats as a result of exercise shortens the time interval between the pictures so that the differentiation of the components is rendered less easy. The staccato pulsation of the first phase might readily escape notice unless one knew what to look for; its presence in the area beyond 10 degrees would be unsuspected unless the muscular exertion was particularly severe. The contractile phase is more readily studied. As the cardiac action decreases in vehemence with rest, the peripheral pattern becomes less and less evident and shortly disappears. The figures in the more central area persist over a longer period and then become fainter.

It would appear that the first phase corresponds to the steep and rapidly moving ascending limb of the pulse curve, while the slower contractile component corresponds to the flatter and longer-descending limb.

Without physical exercise the excursions of the vessels are usually too small to effect entoptic visualization, although at times their movements are vaguely suggested. The diameter of a vessel determines the limits of its excursions, and in the arterioles the vessel caliber is exceedingly small.

Exercise has the effect of dilating the arterioles, thus increasing the vigor and the amplitude of their excursions.

The explanation of this phenomenon must be in the retinal and not in the choroidal circulation, because the macula is free from the pulsating figures. This fact is in keeping with knowledge of the avascular structure of the macula. If the choroid were implicated the pattern would be equally well seen in the macula, for the choroidal circulation is essentially the same behind the macula as in the regions adjacent to it. The pulsating figures are probably caused by the mechanical disturbance of the underlying receptor cells from the exaggerated excursions of the distended blood vessels (Jago). The cells are displaced in one direction while the vessel dilates and in the opposite direction when it contracts. Purkinje and Landois were able to see a pulsatile "illumination" against a dark background. Against this explanation is the fact that the pulsations cause no entoptic disturbance when the eyes are closed. It might be assumed that the swollen vessels cast their enlarged shadows on receptor cells, which are usually free from such shading, and an entoptic image is thereby registered. As will be seen later, the figures which I have described appear confined to the arterioles; if the shadow explanation were true the venules would also cast their images near the pulsating arterioles, which, according to my observation, they do not.

It will be noted that the pulsating vessels seem to run into one another and do not possess the free "terminals" ordinarily seen. This appearance is caused, most likely, by the exaggerated width of the terminal vessels, the space between the free ends being obliterated. There is the inescapable impression that the physiologic functioning of the retinal arterioles undergoes a marked transition at about the 10 degree zone. Elsewhere in the body the amplitude of pulse wave becomes more restricted the farther toward the periphery one goes; in the retina the terminals seem to pulsate more freely than the parent vessels.

The velocity of the pulse wave in the large arteries of the upper part of the body is 6 to 9 meters per second. It must be considerably less in the retinal artery, but even so the velocity of the wave front in the wide parts of the artery is too rapid to be caught by the retinal cells except as a blurr. It is for this reason that the wide parts of the retinal vessels

after strong exercise become evident at once throughout their course from the periphery to the 10 degree zone; there is no sensation here of an advancing pulse wave; there is only the swift blur of uniform expansion manifest all along the line. Clinically, when one observes the pulsations in the retinal arteries in cases of glaucoma one cannot see the advancing pulse wave, because its rate of propagation is too rapid; one merely sees an expansion in caliber simultaneously along the entire extent of the pulsation.

Once the vessel has been dilated, it will remain dilated as long as the pulse wave endures. At the radial artery the duration of the entire pulse wave is 0.6 second. But the peak of the curve, where the distention is greatest, lasts perhaps 0.2 second. Hence the brevity of the first phase in the peripheral visual field; the second phase in this region is likewise brief.

At about the 10 degree zone a decided transition occurs in the character of the pulsations. They become considerably slowed. The passage of the pulse wave from the 10 to the 2 degree zone occupies nearly the whole of the interval between pulse beats. At the rate of 120 heart beats per minute, this would mean that the pulse wave travels across 8 degrees of retinal arc in approximately 0.5 second; 8 degrees of retinal arc represent about 2 mm. of distance; the rate of the pulse wave in the terminal arterioles is therefore dampened to about 4 mm. per second.

It is impossible to discriminate entoptically between an artery and a vein; one can only infer as to whether the retinal pulsations are arterial or venous in origin. Both the first and the second phase of the pulsations are centrifugal, so that in all likelihood they are arterial manifestations. An extension of the arterial pulse into the venous system would induce a wave traveling centripetally. It is unreasonable to assume the existence of a wave such as that described, traveling in a vein in a direction opposite to flow of the blood current.

When one has familiarized oneself with this phenomenon one realizes the disturbance created by the vascular pulsations in the sentient retinal elements and appreciates the attempt at physiologic perfection in keeping the macula free of vessels. If the macula were vascularized, fine visual discrimination and central fixation would be subject to incessant waves of pressure impulses.

I have been able to see the pattern of the retinal pulsations against the uniform illumination of an x-ray viewing box or a white paper held at a distance of about 25 cm. in bright sunlight. Slight pressure over the globe assists in bringing out the picture, but these means are not as satisfactory as clear bright sky as a background. Under certain conditions I have been able to visualize the pulsations even without exercise.

Marshall [5] has observed the occasional entoptic visualization of what he thought was the choriocapillary circulation by looking into the uniformly lighted field of a microscope. I have not been able to confirm his observations, nor have I been able at any time to see circulatory effects which I could ascribe to the choroid per se. It is possible that Marshall had fleeting glimpses of the pattern which I have described and thought it emanated from the choroid. I do not believe that entoptic visualization of the choroidal circulation is possible. The spongy character of the choroidal network, with its superimposed layers of blood vessels, would efface any possible shadows of individual vessels; furthermore, the light would have to be incident through the posterior part of the sclera and not through the pupil as in Marshall's experiment, in order for a choroidal shadow to be cast on the retina.

TENSION ON THE OPTIC NERVE AND ITS EFFECTS ON THE RETINA

It is well known that on extreme horizontal rotation of the eye the retina adjacent to the optic disk is stimulated, presumably through traction by the optic nerve.[6] When the open eyes are thus turned while facing an evenly illuminated white wall, a dark gray oval scotoma ringed by a bright border appears in the region of the blindspot of each; the scotoma is more noticeable in the nasally directed eye. In the dark the effects of optic nerve traction are recognized as the "fiery rings" of Purkinje, which assume a semicircular form on moderate rotation and a completely circular shape on further rotation.

I find that the luminous circles are not equally intense in the two but that the circle of the nasally turned eye is the brighter.[7] It is also larger. If rotation is not quite at the extreme limit, the nasally deviating eye sees a complete circle, but the temporally deviating eye sees only a partially formed circle with the concavity directed inward. Further rotation serves to complete the circle. The color of the circle is a brilliant blue-white. It will be seen that the enclosed area is not blank but is colored a pale blue, which is less conspicuous than the outlines of the circles, the intensity decreasing toward the center. The circles include within their area the locus of the blindspot. They are considerably larger than the blindspot as it is perceived entoptically by the usual methods, and there is much in favor of the assumption that the circles are due to

5. Marshall, C. R.: Brit. J. Ophth. **19**:177, 1935.

6. (*a*) Purkinje, J.: Beiträge zur Kenntnis des Sehens in subjectiver Hinsicht, Prague, J. G. Calve, 1823, p. 78. (*b*) Czermák, J.: Physiologische Studien, Vienna, 1854, pt. 1, p. 42; Gesammelte Schriften, Leipzig, Wilhelm Engelmann, 1879, vol. 1, pt. 1, p. 281. (*c*) von Helmholtz,[2] vol. 2, p. 9.

7. Friedman, B.: The Mechanics of Optic Nerve Traction on the Retina During Ocular Rotation, Arch. Ophth. **25**:564 (April) 1941.

the mechanical stimulation of the peripapillary retinal structures by the taut nerve. It is difficult to visualize the blindspots within the luminous circles.

I have shown elsewhere [7] that when the eye is directed nasally traction is exerted on the part of the retina which is temporally adjacent to the disk, whereas the area nasally adjacent is under compression. When the eye is turned temporally, traction is exerted nasally to the disk, while the retina temporally adjacent to the nerve becomes compressed. From anatomic considerations I have shown that the maximum of traction to which the retina thus becomes physiologically subjected falls on the area of retina temporally adjacent to the disk on extreme nasal rotation. This explains the greater vividity of the luminous circles in an eye turned nasally. The luminous circles seem to include the area under compression as well as that under traction.

The luminous circles appear to be displaced in the entoptic field from the position of the blindspot toward the direction of the ocular movement. Thus, when the eye deviates nasally the nasal edge of the circle is projected to the center of the entoptic field; when the eye is turned temporally the luminous circle also moves temporally, and so on. This indicates that the tension exerted on the peripapillary portion of the retina in any position of extreme rotation is on that part which lies opposite the direction of gaze.

Slight pressure over the globe during rotation will inhibit the luminous circles. The inhibition apparently is due to backward displacement of the eye from the pressure, the tension on the optic nerve being thereby eased. If the hand is suddenly removed while the eye is in extreme rotation, the luminous circle may spring into being. The increased intraocular tension brought about by external pressure exerts counterpressure on the retina and may so assist in inhibiting the luminous circles.

I have been unable to induce the luminous circles by direct upward gaze. Direct downward rotation induces only a faint suggestion of the circles; the tension on the nerve, which depends on the position of the globe, at this angle is barely sufficient to evoke the circle.

If close attention is paid to the luminous circles, it will be observed that in positions of extreme rotation there are a number of bright striae, of a blue more vivid than the pale background, which cross the circles. Their locations and shapes vary according to the position of the eye (fig. 7).

When the eye is turned nasally the luminous striae assume the form of five or six arcuate lines which occupy the lower third of the circle. The concavities of the arcs face upward, and they seem to emanate from a point on the lower nasal circumference of the circle, whence they spread out fanwise in a more or less horizontal direction. The apex

of the diverging lines points in the same direction as the movement of the eye. When the eye is turned temporally the arcs reverse their direction and form. When the eye faces down and out these luminous striae assume the form of four or five arcs nested within each other, their convexities facing down and out. The ends of the arcs stream backward like curved fingers; the fronts almost overlap. The fronts of the arcs point in the direction of ocular rotation. Similar figures are observable when the eye is displaced up and in, up and out, and down and in. The figures are seen most readily when the eyes are in the horizontal positions, less easily when they are in the depressed positions and least readily when they are in the elevated positions.

The striae are not always seen with uniform clarity. They are rather obscure when either eye is down and in. At times only parts of the

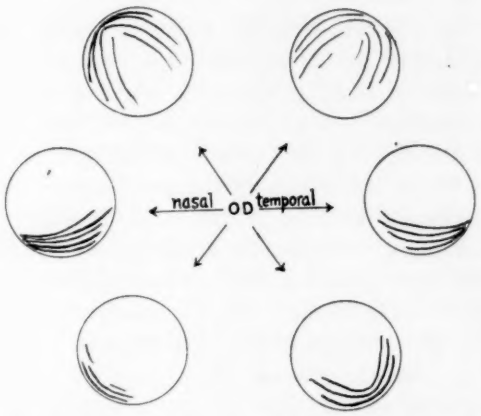

Fig. 7.—Appearance of the luminous striae as they present themselves to the right eye of the observer. The large circles diagrammatically represent the luminous circles in the cardinal positions of gaze. The luminous striae are depicted as they cross the circles in the various positions of the eye.

figures are visible, and there may be some difference between the homologous figures of the right and of the left eye both in intensity and in form. When my left eye turns down and out the arcs are similar to those seen on lateral rotation except that the diverging ends of the striae face up and nasally. Usually the ends of the arcs are easier to perceive than the fronts. In the elevated positions of the eye, the striae are extremely difficult to observe and even the luminous circles are visible only after the eyes have been rested in a dark room for some time. All these phenomena are perceived with particular clarity if the experiment is done under the bed coverings before the eyes have opened when one awakens early in the morning. Frequent repetition causes failure of the figures to reappear, and an interval of recovery is required before the circles and arcs again become visible. The element of dark adapta-

tion does not enter into the question of fatigue, since the experiment is performed in the dark.

Just how the luminous striae are formed is not clear. At first I believed them to be the result of traction on the retinal nerve fibers. The striae appear to lie in the area of retina which is under traction, but the configurations of the striae do not correspond to the fibers which would be under traction. The association of external pressure by the bent nerve on the sclera suggests itself. (Von Helmholtz [8] proposed such an explanation for the "fiery rings" themselves.) The tautness of the retina would enhance "phosphene" effects provided by such outside pressure. Extrascleral pressure at that spot probably produces creases in the underlying retina, and the appearance of the semicircular striae is consistent with this idea. Thus, it is possible that the striations represent, not the course of retinal fibers, but folds in the retina.

There are some inconsistencies which are still more difficult to explain. For example, the striae induced by horizontal rotation are at no time in the form of such large arcs as are seen with the eyes in the other cardinal positions, yet horizontal rotation produces the greatest displacement of the nerve head. These incomplete striations are seen only in relation to the lower part of the luminous circles; that is, they represent the projection of the upper halves of the folds; the other halves of the arcs are missing. An anatomic fact possibly connected with the exclusive production of the lower striae is the existence of firm adhesions between the upper nerve bundles and the contiguous periosteum of the optic canal roof: By their resistance to displacement these upper fibers may locally exaggerate the creasing effect in the retina. Nevertheless, this explanation does not account for the complete absence of upper arcs. As I have stated, the striae are visible as similar incomplete circles diverging from one point when my left eye is turned down and out. The difficulty in seeing the luminous striae while the eyes are elevated may be due in part to the lack of pull on the upper fibers in those positions. More investigation of these figures is required.

Other effects of optic nerve tension may be seen before a bright light when the eyes are closed and rotated horizontally. These have been described by Czermák,[6b] but a few observations may be added. The nasally deviating eye sees an enlarged, evenly colored, deep blue circle with a part of the nasal border missing, so that the figure has a crescentic appearance. The usual bright blue and often clearcut outlines of the luminous circle are not seen. The temporal border of the crescent is edged with a broad halo of orangish-light; the nasal border gradually fades into the colorless hollow of the crescent. The temporally turned eye perceives a smaller, ill defined, reddish orange circle of much less intensity; its center at times contains a bluish tinge. There appears to

8. von Helmholtz, H., cited by Brøns, J.: Acta ophth., 1939, supp. 17.

be no loss in the integrity of this circle. When the eyes are brought into closer proximity to the light the orange tones in the circles become intensified and the blue fades considerably. The circles persist as long as the extreme lateral rotation of the eyes is maintained, and they can be seen to change their size and intensity as the tension of the rectus muscles wavers. The luminous arcuate striations are not visible under these conditions.

I have noted a crescentic defect in the nasal part of the circular scotoma which is induced by turning the open eye nasally in front of an illuminated white wall.

There is much in common between these circles, the luminous circles and the phosphene circles produced by digital pressure on the sclera. The phosphene circles may be provoked simultaneously with the others for comparison.

When the sclera is transilluminated by an ophthalmoscope light for visualization of the retina and lateral movements of the eyes are made, it is impossible to see the luminous circles or striae, because they are outshone by the brilliant light of the retinal background. Entoptic observation of the vertical macular vessels for changes in angulation while the eyes are rotated does not disclose evidence that the traction effects extend to the macular region. Nevertheless the presence of the luminous circle of the nasally turned eye in the center of the entoptic field would indicate that during nasal rotation the effects of optic nerve traction extend right up to and possibly even beyond the macula. This is considerably past the limits which were previously stated.[7]

BLUE RING DUE TO PROLONGED PRESSURE

Prolonged digital pressure over the eye induces a "pressure ring" in the form of a broad circular band of blue. The pressure should be sufficiently strong to cause slight discomfort and must be maintained continuously until the blue figure appears. In its completed form the pressure circle is shaped somewhat like a broad automobile tire flattened in its vertical diameter. The phenomenon generally begins to be seen after about three minutes of pressure as two spots of blue color, one nasally and one temporally. Slowly these expand and each assumes the form of a broad arc. The figure continues to grow until the arcs coalesce into the astonishing blue circle by a slow creeping motion which reminds one of the behavior of fluid seeping in between two plates of glass (fig. 8). Completion of the phenomenon requires about a minute. Once the spots become evident they will continue their evolution into the circle even if the pressure over the eye is removed. The center is oval and is devoid of color; it is sharply demarcated and corresponds approximately to the macular limits. Measured from the fixation point, it extends about 2 degrees above and below and about 3 degrees on each

side. The periphery is also sharply outlined, and it reaches the 10 degree zone vertically and about the 12 degree zone horizontally. There is no indication that the blindspot is involved. The color is a deep, fully saturated blue, more vivid at the margins of the figure but otherwise uniform. The figure persists for about five minutes and lies in front of the visual field of the open eye as a relative ring scotoma through which objects are seen indistinctly, as through a blue filter. The central uncolored area allows objects falling upon it to be seen in their natural colors, although hazily. The vividness of the figure is accentuated by closing the eye.

I cannot say what underlies the production of this phenomenon. The subjective impression is that of a temporary perimacular detachment of the retina. It is curious, indeed, that glaucomatous patients, who have states of acutely increased tension, and persons who are subjected to pressure bandages do not complain of similar entoptic visions.

On one occasion, several days after the performance of a number of experiments with this phenomenon, the blue pressure ring came into

Fig. 8.—The stages of the blue pressure ring.

being spontaneously in one eye, much to my consternation. I had done nothing at all to provoke it. The phenomenon faded away gradually, as it always did, without further discomfort, but I am led to believe that experiments of this sort are not without the danger of leaving permanent sequelae, and I should caution against too much enthusiasm toward their repetition. The fact that the blue ring, once begun, goes on to completion even after the removal of pressure indicates the malignant nature of the conditions inaugurated.

I cannot explain why the pressure ring should be so strictly confined to the 12 degree and the 10 degree boundary and why the outlines of the figure should be sharply delimited. Still more inexplicable is the absence of the blue color from the macular area. Blue is the easiest color to evoke by means of nonspecific stimuli [9]; that the pressure ring should be blue rather than another color is therefore not too surprising. The figure speaks for a distinct anatomic differentiation between the retinal area corresponding to the blue ring and the macular region centrally as well as the remainder of the retina peripherally. Since the most obvious

9. Friedman, B.: Blue Arcs of the Retina, Arch. Ophth. **6**:663 (Nov.) 1931.

effect of prolonged pressure on the eye is the production of ischemia, one might conclude that this zone is particularly sensitive to deprivation of oxygen. It is possible that the clinical counterpart of the phenomenon is to be found in the ring scotoma of syphilitic chorioretinitis and retinitis pigmentosa. The situation of the pressure oval corresponds roughly with the zone of maximum rod population which Østerberg [10] has described. Much more needs to be known concerning this phenomenon for its meaning to become clear.

THE PREVALENCE OF BLUE IN ENTOPTIC PHENOMENA

The receptors for blue are the most easily activated by nonspecific stimuli; other colors usually require actual light as the irritant.[8] Circular waves of blue color may be seen in the dark by the dark-adapted retina; they start at the periphery and move inward toward the macula as a concentrically contracting solid circle, disappear at the macula and begin again at the periphery.[11] At times the direction of movement in my eyes is reversed. No external pressure is required to bring these waves out; the internal changes in the eye constitute sufficient stimuli. The blue color is to be seen in the traction circles induced by the pull of the optic nerve on the retina, in the traction striae and in the tiny flashes seen before the eye during the act of reading. The same blue color is common to the pressure rings which I have described and to the blue arcs of the retina. The pressure phosphenes of the retina are blue, although usually of a paler hue.

It has been said that in the metamorphosis of color vision the primitive color sensation was blue; certainly the prevalence of blue in entoptic observations suggests for it a special role in the physiology of color vision.

Another phenomenon I have observed is in the form of a bluish violet spot which flashes before my eye usually during the act of reading. The figure is circular with jagged edges. It is small, about the size of a match head, as it is seen projected against the page, and it seems to sparkle for perhaps a half-second. It disappears as abruptly as it appears. It is seen by either eye, but not by the two simultaneously, and lies at times in the paramacular region of the field and at others in the neighborhood of the disk. It is not induced by extensive or rapid ocular movements. The blue color of this evanescent figure is similar to the blue noted in the other entoptic images mentioned.

THE CHOROIDAL PIGMENT

When the ophthalmoscope bulb is held against the closed eye and the attention is directed to the region of the light source, disregarding

10. Østerberg, G.: Acta ophth., 1935, supp. 6, p. 1.
11. Edridge-Green, F. W.: J. Physiol. **42**:428, 1911.

the vascular tree and the rest of the fundus one can see a most beautiful picture of the choroidal pigment against a blood-red background. The ruby color of the background obviously comes from the color-filtering properties of the blood contained in the skin, conjunctiva and choroid, through which the light has passed. The arrangement of the pigment is in small and large groupings of still smaller circular black islands, and the pigment is seen much more distinctly and strikingly by this method than objectively. The pigment disposition is so characteristic of choroidal pigmentation as seen in the patient's eye that the patterns cannot be interpreted otherwise (fig. 9).

The choroidal and retinal pigments cast their shadows from behind on the rods and cones, and the process is truly what Marshall termed "looking backward." The pigment is seen for a variable distance around the ophthalmoscope light, the distance depending on the intensity of the

Fig. 9.—Manner of observing the choroidal pigment: *C*, choroidal pigment; *P*, pigment layer of retina; *R*, retina; *V*, retinal vessel.

illumination. Lateral transmission of the light through the intervening tissue stratums is effective only for a short distance. The only rays which can render the choroidal pigment visible are those which impinge on the rods and cones from behind; hence the localization of this phenomenon to the area of contact with the lighted bulb. In all other entoptic experiments the incident light stimulates the retina from the natural direction.

Ordinarily one pays no attention to the image of the choroidal pigment at the point of contact of the ophthalmoscope bulb. To visualize the vascular tree the light continues into the eye past the choroid and retina at the area of contact and strikes the other rods and cones in a forward direction, illuminating the entire retina and permitting the retinal vessels to cast their shadows in the normal direction. The choroidal pigment and the vascular tree may be seen simultaneously.

The red color of the light at the point of contact is of a considerably deeper shade than the red-orange color of the rest of the retina when viewed entoptically. The light which reaches the rest of the retina must travel a longer distance and must pass through the thickness of the retina twice. The change in color is due to the decrease in intensity of the light.

THE RETINAL PIGMENT

The retinal pigment should theoretically be seen at the same time that the choroidal pigment is being observed. It is very fine and is uniformly distributed and should become evident wherever the denser choroidal pigment does not mask it, but one cannot differentiate it from fine choroidal stippling. The incident light in observation of the retinal pigment also comes from behind the layer of rods and cones. The area of visibility of the retinal pigment must be in the immediate neighborhood of the point of illumination. Elsewhere the retinal pigment cannot be seen for the same reasons which have been given in connection with the limits of visibility of the choroidal pigment.

The macula is readily seen to possess a granular appearance when viewed entoptically by the usual methods, and at times a similar texture is noted in the rest of the retina. The granular structure thus seen must not be thought of as being produced by the retinal pigment; the pigment layer cannot cast its shadow on the retina by light which strikes from an anterior or an anterolateral direction, and it is a physical impossibility in the normal eye to transilluminate the macula from behind.

PHENOMENA ASSOCIATED WITH THE ENTOPTIC VISUALIZATION OF THE VASCULAR TREE OF THE RETINA

The most effective method of visualizing the retinal vessels entoptically is to remove the head of the ophthalmoscope, leaving the condensing cap in place, and then gently move the instrument over the closed lids against the scleral portion of the globe (Eber [12]).

If digital pressure is applied to another part of the sclera while the vascular pattern is thus being observed, the image fades quickly. The disappearance occurs in a few seconds or less, the time depending on the strength of the pressure. The vascular tree fades out first in the area of the retina corresponding to the projected point of pressure, no matter in what part of the field this may be. There seems to be no correlation between the invariable primary nasal loss of field as the result of glaucomatous pressure and the entoptic loss of field from digital pressure. An interval of recovery must ensue after pressure before the vascular tree reappears.

12. Eber, S.: Am. J. Ophth. **5**:973, 1922.

When the ophthalmoscope is moved against the eye the image of the vascular tree moves in the same direction. If attention is directed to the macula, the finely granular structures in this region may be seen to cast shadows which move in the opposite direction (von Helmholtz). I believe that the explanation of this phenomenon is as follows: The motion of shadows cast by retinal structures depends on the obliquity of the incident light and on the distance between the body which casts the shadow and the rod and cone layer of the retina. Since the thickness of the retina in the region of the vessels is about four times the thickness of the retina at the bottom of the macular concavity, the shadows of the vessels will move over an arc much larger than the arc through which

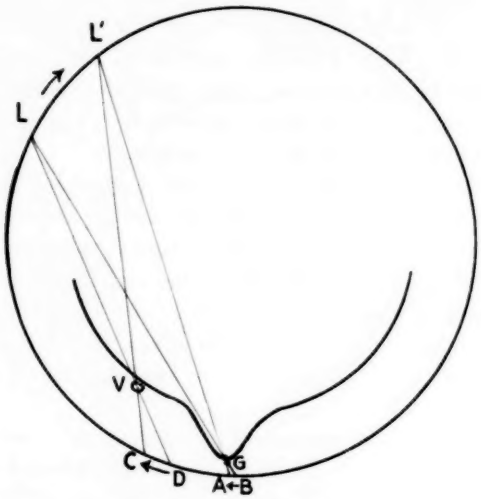

Fig. 10.—Parallactic displacements of shadows cast by a vessel in the relatively thick paramacular portion of the retina and by a granule in the thin macular portion. The source of light moves from *L* to *L'*. The paths of the shadows are from *D* to *C* and from *B* to *A*. The brain in this case interprets the movement of the vessel shadow as from *C* to *D*, but the movement of the granule shadow is seemingly from *B* to *A*.

the macular shadows pass. This gives rise to a parallactic illusion which is akin to the "with" and "against" motion of distant and near objects when viewed from a moving train.

The vascular tree may be visualized while the eye is kept open. The sight may be directed toward the Snellen chart, and the image of the test letters may be perceived in relation to the avascular macula. This procedure serves as a means of demonstrating the astonishingly small size of the letter images. It is easy to outline the borders of the macula against a tangent screen. The entire vascular pattern at one

time stands out clearly against the dark background; this method may be termed "subjective vascular scotometry" and might find a limited application by selected trained observers.

When the closed eye is caused to see the retinal vessels by application of the ophthalmoscope from the temporal side while the other eye is kept open, the vessels seem to be observed by the open eye as a network against the objects in the room. When the choroidal pigment is seen under similar conditions in a semidark room the pigment seems projected into the temporal field of the open eye. Generalizing, it may be stated that if an entoptic stimulus falls on the extreme part of the nasal entoptic field of one eye, it will be projected to the temporal field of the other eye and will appear to be seen by the other eye. This is so probably because an external object which would theoretically fall on the site of entoptic stimulation would actually be seen only in the temporal field of the opposite eye; the nose would interfere with its visibility in the extreme part of the nasal visual field of the stimulated eye. The object would thus not be included in the mutual field, and an entoptic stimulus at that point would be referred to the corresponding retinal point of the other eye. The mind seems to prefer projection of an image to the temporal field rather than to the nasal field. The following experiment will illustrate the point: In a dark room, the left eye is closed and the glowing tip of a cigaret is held at arms length and brought into the locus of the right blindspot, where it will disappear. With the cigaret tip kept motionless, the left eye is opened. The light will fall on the nasal field of the left eye, but it will appear to be seen by the right eye. Its failure to register in the temporal field of the right eye will not even be noticeable.

The vascular patterns of the two eyes may be seen simultaneously by the use of two ophthalmoscopes. A beautiful example of visual field rivalry becomes evident. One image fades as the other gains dominance. Even the maculas cannot be made to fuse entoptically, which is rather surprising. The individual vessels in each eye may be identified by moving the ophthalmoscopes simultaneously in opposite directions; the right and the left vascular tree will also move in directions opposite each other. The entopic image of the macula follows the motion of the eye.

The retinal vessels may be visualized in a number of rather interesting ways aside from the orthodox methods. They may be seen by rapidly shutting and opening the eye a number of times in a brightly lighted room while the vision is directed toward a white wall. They may be seen when the eye looks through a red-free filter at a white paper held about a foot away and the eye is rapidly closed and opened. The vessels appear black when the eye is open and white when it is closed. If the eye looks into a bright light and the light is suddenly extinguished, the

vascular tree becomes evident. A red or green glass before the eye accentuates the picture.

I am frequently annoyed by the picture of the retinal vessels before my eye while I am performing retinoscopy in the dark room.

If the retinal vessels are visualized in a dark room immediately after exposure of the eye to a bright light, the retinal background assumes a mottled, marble-like appearance, with black granules forming the design against greenish blue interstices.

APPENDIX

It is possible to determine whether an opacity lies in front of or behind the pupillary plane by the parallax method of Listing. Suppose that *c*, *p* and *v* in figure 11 *A* are opacities on the visual axis lying

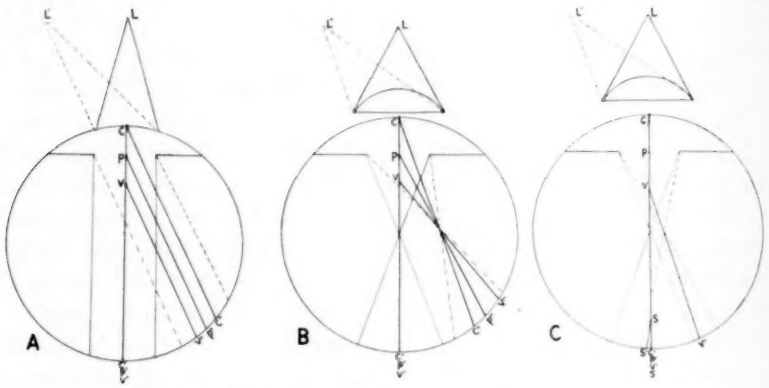

Fig. 11.—*A*, the parallactic displacement by parallel rays of shadows cast by opacities in the ocular media. *B*, the parallactic displacement, by converging rays of shadows cast by opacities in the ocular media. Note that the opacities lie in front of the crossing points of the rays. *C*, the parallactic displacement of shadows cast by opacities in the vitreous. One opacity (*v*) lies in front of the crossing points of the rays; another (*s*) lies behind the crossing points of the rays. The separation of the shadows cast by *v* is shown by the distance *v'v''*. The separation of the shadows cast by *s* is measured by *s's''*; this distance is shorter and lies in the opposite direction.

respectively in the cornea, the pupil and the vitreous. *L* is a homocentric light source at the anterior focal point of the eye. The rays which strike the retina are parallel, and *c*, *p* and *v* will cast their shadows on one common spot, the fovea. The shadows will be superimposed on each other and will occupy the center of the entoptic field of vision, which is bounded by the pupillary margins. Now, if the light source is moved toward the left, to *L'*, the positions of the shadows relative to one another will change. The opacity *p* will still occupy the center of the field and

will not appear to be displaced; *c* will shift to the right side of the entoptic field, but mentally it will be projected to the left, that is in the same direction as the shift of the light source, and the parallactic displacement will be seen as a positive shift. The change in position of *v* will be to the left, but the shadow will be interpreted by the brain as moving toward the right, or opposite to the movement of the light source, and the parallactic displacement will be negative.

When a strong plus lens is held before the eye for the entoptic observation of opacities, the rays entering the eye are strongly convergent and cross before striking the retina. The parallactic displacement of opacities in this instance will be the reverse of that of parallel rays; that is, *c* will shift to the left and will give a negative parallax, while *v* will shift to the right and will give a positive parallactic movement. The opacity *p* will not seem to shift.

A more exact method of locating an opacity depends on the duplication of its shadow by the use of two light sources which cast parallel rays on the retina (Brewster). Modifications of this method were devised by Donders and by Doncan. The farther forward the opacity lies the farther apart will be its twin shadows. (This is evident from figure 11 *A*. *L* and *L'* may be considered as two simultaneous, separate light sources.)

When a strong plus lens is used before the eye in the manner indicated in the experiments described, the rays entering the eye are convergent and will cross at a level anterior to the retina. This will cause the reduplicated shadows of a corneal opacity to lie closer together than the doubled shadows of an opacity in the vitreous (fig. 11 *B*). If, however, the opacity lies in the vitreous behind the level of the crossing point of the rays, its doubled shadows will move closer together (fig. 11 *C*). The distances between these shadows, therefore, will depend in part also on the distance of the crossing point of the rays from the retina, a distance which is practically impossible to determine in actual experiments. It is obvious, therefore, that accurate localization of an opacity cannot be obtained unless the rays traversing the eye are parallel when they reach the retina. Unfortunately, the corneal channels which I have described are only poorly recognizable when the rays are parallel in the vitreous, so that proof of their size and plane of situ cannot be determined exactly.

However, it is possible to measure the distance between the duplicate shadows of a particular channel by means of a pair of divider points and to compare this distance with the separation of the twin shadows of a tear corpuscle. The respective separations are found to be nearly equal, indicating that the channels are definitely within the cornea. The channel shadows are slightly farther apart than the tear corpuscle shadows, prov-

ing that they lie behind the anterior surface of the cornea. The separation between the channels is considerably smaller than the distance between the doubled shadows of a vitreous strand, suggesting that the channels lie anterior to the vitreous.

The measurements are best made by interposing a vertical pane of glass at the plane of conjugacy of the condensing lens-eye system. The plane of conjugacy is found by moving a point of the dividers toward the eye until its shadow becomes sharp and single; the glass is moved to this distance. The gaze must always be directed toward the light source. The divider points are now held against the glass and separated until they just cover the shadows which are being investigated.

6 West Seventy-Seventh Street.

Clinical Notes

FACTORS WHICH INFLUENCE THE OBJECTIVE VISIBILITY OF OPACITIES IN THE OCULAR MEDIA

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Every ophthalmologist has encountered failure in attempting to discover an opacity in the vitreous which was strikingly manifest to the patient. On the other hand, no difficulty whatever is experienced in visualizing some opacities. A number of simple factors operate in connection with the objective visibility of opaque or semiopaque obstructions to the transparency of the ocular media.

The light rays by which an opacity is detected arise from two sources. Firstly, incident light from the examiner's instrument strikes the anterior surface of the opacity and illuminates it directly; some of the rays are reflected back to the observer, who obtains a more or less bright image of the anterior surface. Secondly, light is reflected from the retina to form a luminous background for the opacity. If the opacity is dense the retroillumination accentuates its outlines sharply by contrast. If the opacity is semiopaque it will become conspicuous by virtue of its uneven refraction of the rays which strike it from behind. Irregular light and dark zones will alternate in its structure, and the edges will appear highly refractile.

When the observer uses the plane retinoscope held at arm's length the opacity is recognizable chiefly by contrast with the reflected illumination from the retina, and it is seen as a dark body against a dull red background. Practically no light is reflected to the observer's eye from the anterior surface of the opacity under this condition because the opacity is a poor reflector and its surface is small. Furthermore, the light in its journey back to the observer has lost most of its intensity. If the opacity lies within the vitreous, its anterior surface will receive some additional light from the rays which have been scattered within the eyeball; if the opacity is in the lens or cornea its anterior surface will receive rays from the mirror only. An opacity in the lens or the cornea will stand out in sharper contrast against the fundus glow than an opacity in the vitreous, and it will be more readily discerned.

When the retinoscope is held close to the patient's eye much more light is reflected to the examiner from the anterior surface of the opacity, and it is no longer seen as a dense black shadow. If the opacity lies well forward in the eye its details will be blurred unless the observer has an active accommodation.

Another factor relates to the ease with which a semitransparent membrane, such as cellophane, may be observed when it is held at a distance from a light source, whereas when it is held close to the light source it becomes all but invisible. In a weak light a minor reduction in light

transmission is easily perceived, while in a stronger light the same degree of reduced transparency becomes difficult to detect.

The retinoscope is usually successful as an instrument for detecting imperfections in the media because it provides a relatively weakly illuminated background for the opacity; the retroillumination is not likely to shine through a diaphanous structure with such intensity as to render it difficult of perception. In this respect the concave mirror is less advantageous than the plane mirror.

When the oculist uses the electric ophthalmoscope he generally focuses down on the opacity by means of a suitable plus lens in the aperture. He then views the opacity by a strong direct light as well as by retroillumination. If the opacity is fairly transparent and lies close to the retina it will be difficult to discern because the brilliant reflection from the retina pierces the opacity without producing noticeable refractive irregularities and the rays from the retina tend to outshine the rays which are sent back from the anterior surface. If the same opacity is more distant from the retina the retroillumination is less intense and will consequently interfere less with the visibility to the observer. Unless an appropriate plus lens is employed in the ophthalmoscope an anteriorly placed opacity will form a blurred image on the observer's retnia and may escape detection.

When the ophthalmoscope is held at a distance it acts as a retinoscope would act.

An opacity in the vitreous is viewed by the observer through a magnifying system consisting of the patient's lens and cornea. The closer the opacity lies to the lens the less will be its magnification; the closer it lies to the retina the greater will be its magnification. However, if the patient's eye is highly myopic and the opacity lies behind the posterior focus of the eye, the opacity will appear indistinct and will remain so until the appropriate minus lens is placed before the patient's cornea. Interpolating the minus lens has the effect of lengthening the focus of the magnifying system, and the opacity is thus caused to fall within the focal distance. An opacity in the lens will suffer magnification only by the cornea, while a corneal opacity will receive no magnification at all.

It is needless to remark that, all other conditions being equal, an opacity will be noticeable in direct proportion to its size.

The texture of the opacity is important in regard to its visibility. The poor reflective power of a semitransparent opacity is counterbalanced by the irregularities in its capacity to transmit light. An imperfectly formed window pane is more readily noticeable than one whose transmissibility is perfectly uniform. If the opacity is rather solid, for example a blood clot in the vitreous or in the aqueous or a precipitate on the posterior corneal surface, and the observer's eye is focused by the lens of the ophthalmoscope to the proper depth, the observer will see the opacity chiefly by direct illumination and will be able to recognize the red color of the blood or the white of the precipitate. The opacity in this case must lie directly in the beam of the incident light. If the ophthalmoscope is moved slightly the opacity will become illuminated from behind by reflected light from the retina or the iris; it will appear black because only the shadow is visible.

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Ophthalmologic Reviews

EVIDENCE FOR CIRCULATION OF THE AQUEOUS AND ITS RELATION TO GLAUCOMA

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It has been recognized for many years that an understanding of the problems of the formation and reabsorption of the aqueous is the only possible basis for the understanding of glaucoma. However, in spite of the mass of clinical and experimental evidence to show the mode of circulation of the aqueous, most ophthalmologists still are content to discuss their favorite theories concerning the etiology of glaucoma without any regard to such evidence. This paper is an attempt to summarize this material and to present an etiologic classification of glaucoma based on such data.

I. SOURCE OF THE AQUEOUS

Modern consideration of the source of the aqueous began with the great work of Leber [1] and has largely been elucidated by Friedenwald and his co-workers. Leber showed experimentally that the ciliary body is the chief source of the intraocular fluid. When the acid dye fluorescein is injected intravenously, and some of the aqueous withdrawn from the anterior chamber, the dye is observed to enter into the eye from the ciliary processes.

Although the ciliary body has been generally accepted as the anatomic source of the aqueous, there has been considerable controversy as to the process of its formation. Three theories have had strong adherents. The filtration theory held that there was a small flow of fluid from the capillaries of the ciliary body, and possibly some from the iris vessels, because the hydrostatic pressure within these vessels was higher than the colloid osmotic pressure of the blood plus the intraocular pressure. The dialysis theory implied that the aqueous was a fluid in physicochemical equilibrium with the blood, that the capillary walls acted as semipermeable membranes and that the system manifested the characteristics of Donnan's equilibrium. The secretion theory as championed by early workers held that the secretion of aqueous was similar to that

From the Illinois Eye and Ear Infirmary.
Aided by a grant from the Kellogg Foundation, of Battle Creek, Mich.

1. Leber, T.: Die Cirkulations- und Ernährungsverhältnisse des Auges, in Graefe, A., and Saemisch, E. T.: Handbuch der gesamten Augenheilkunde, Leipzig, Wilhelm Engelmann, 1903, vol. 2, pt. 2.

resulting from glandular function. The term secretion, however, as used today is used also to refer to the transfer of water or other substances across a tissue barrier at the expense of cellular energy.

Much of the controversy was based on chemical studies of the aqueous and of the blood. The dialysate theory was dominant for many years, but even Duke-Elder,[2] who first applied Donnan's theory to the aqueous, has more recently found that the aqueous deviates from a dialysate. It contains less urea,[2a] creatinine and sugar than the blood and contains ten times the concentration of ascorbic acid found in the blood. In addition, Meyer [3] has shown that the vitreous fluid contains a mucoid, which he calls hyaluronic acid, which is present in the aqueous but not in the blood. Furthermore, experiments with acid and basic dyes have shown that the ciliary body is permeable in both directions to acids and neutral substances but impermeable in both directions to nonreducible basic dyes and that the ciliary body is permeable to water in only one direction, from the blood to the aqueous, even under increased pressure. Friedenwald and associates [4] introduced various dyes into the ciliary body and found that acid dyes (anions in solution) fill the stroma and do not penetrate into the epithelium, while basic dyes (cations in solution) introduced into the epithelium fail to enter into the stroma. This unidirectional permeability could be destroyed by poisoning with cyanide. Thus Friedenwald established the presence of a vital barrier in the ciliary body between the stroma and the epithelium. But even more remarkable is his determination, by the use of p_H indicators, of the difference of electrical potential between the two portions capable of causing the movement of water across the negatively charged membrane in the direction of the more positively charged epithelium. The substances capable of producing such a difference in tissue potential are the oxidizing and reducing enzymes taking part in the metabolism of the tissues.

The epithelium contains an excess of enzymes important in oxidation, while the stroma contains an excess of reducing agents and a series of redox substances important in the interaction between the two substances. These substances are indophenol oxidase in the epithelium

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2. Benham, G. H.; Duke-Elder, W. S., and Hodgson, T. H.: Osmotic Pressure of Aqueous Humor in Normal and Glaucomatous Eyes, J. Physiol. **92**:355, 1938.

2a. Adler, F. H.: Is Aqueous Humor a Dialysate? Arch. Ophth. **10**:11 (July) 1933.

3. Meyer, K.: Nature of the Ocular Fluids: Hexosamine Content, Am. J. Ophth. **21**:1083, 1938.

4. Friedenwald, J. S., and Stiehler, R. D.: Circulation of the Aqueous: VII. A Mechanism of Secretion of the Intraocular Fluid, Arch. Ophth. **20**:761 (Nov.) 1938. Friedenwald, J. S., and Pierce, H. F.: Circulation of the Aqueous: II. Mechanism of Reabsorption of Fluid, ibid. **8**:9 (July) 1932.

and ascorbic acid [5] and glutathione in the stroma. Epinephrine is considered to be a potential activator of the oxidative interaction between the oxidase system of the epithelium and the interstitial mediators of the stroma.[6]

The brilliant work of Friedenwald and his associates has ended the controversy as to the relative merit of the three theories of the formation of the aqueous. His own conclusion that "no unitary answer can be given to these questions and that thermodynamic and osmotic forces, hydrostatic and finally vital forces enter into the picture" should suffice.

II. CIRCULATION OF THE AQUEOUS

Predicated on the evidence that vital activity is concerned with the formation of the aqueous, a through and through circulation may be assumed to exist. The actual evidence for such a circulation is based on experimental and clinical data.

A. *Experimental Data.*—1. Substances in solution or suspension appear in the anterior chamber within a short time after introduction into the vitreous. Knies,[7] H. Gifford,[8] Friedenwald and Pierce [9] and others have presented such evidence. Kinsey and associates [9a] have recently studied the rate of entrance of radioactive isotopes of sodium, chloride and phosphorus. They appear in the anterior chamber at a rate calculated to be approximately equivalent to 4 cu. mm. per minute of whole aqueous.

2. Experimental hindrance to the exit of fluid from the anterior chamber by mechanical means or by neutralizing the osmotic factors in Schlemm's canal has led to an increase in intraocular tension, this increase indicating that a continuous circulation must be present. Friedenwald and Pierce [9] introduced a cannula which was connected to a reservoir into the anterior chamber of an animal's eye and kept the intraocular pressure stationary by raising the level of the reservoir.

5. Friedenwald, J. S.; Buschke, W., and Michel, H. O.: The Role of Ascorbic Acid in the Secretion of the Intra-Ocular Fluid, Tr. Am. Ophth. Soc. **37**:310, 1939.

6. Friedenwald, J. S., and Buschke, W.: The Role of Epinephrine in the Formation of the Intraocular Fluid, Am. J. Ophth. **24**:1105, 1941.

7. Knies, M.: Ueber die Ernährung des Auges und die Abflusswege der intraokularen Flüssigkeiten, Arch. f. Augenh. **7**:320, 1878.

8. Gifford, H.: Ueber die Lymphströme des Auges, Arch. f. Augenh. **16**: 421, 1885-1886; **26**:308, 1893-1894.

9. Friedenwald, J. S., and Pierce, H. F.: The Circulation of the Aqueous: I. Rate of Flow, Arch. Ophth. **7**:538 (April) 1932.

9a. Kinsey, V. E.; Grant, W. M.; Cogan, D. G.; Livingood, J. J., and Curtis, B. R.: Sodium, Chloride and Phosphorus Movement and the Eye, Arch. Ophth. **27**: 1126 (June) 1942.

They measured the outflow of the intraocular fluid with a bubble manometer and found it to be 1 cu. mm. per minute. They then introduced some of the animal's own serum into the eye and found that the outflow was interfered with and that the tension rose. Kronfeld [10] performed somewhat similar experiments and found the rate of flow to be 1 cu. mm. He used oil to obstruct the outflow.

3. In measuring the amount of dilution by aqueous of the venous blood from the veins draining Schlemm's canal, Troncoso [11] collected blood from the episcleral veins, determined the relative proportion of serum to erythrocytes and compared the dilution with other venous blood. From the resultant values he calculated the rate of flow of aqueous to be 2 to 3 cu. mm. per minute.

B. *Clinical Evidence.*—1. Inflammatory and neoplastic cells arising in the eyeball behind the iris usually are deposited on the posterior corneal surface, a fact indicating that they are carried there by the circulating aqueous.

2. The evidence of clinical glaucoma indicates that, except possibly in a few forms, increased intraocular tension is due to failure of reabsorption of aqueous. The exceptions, including lenticular dislocation (posterior), concussion glaucoma and the glaucoma of epidemic dropsy, are as yet not completely understood. They may be associated with increased formation of fluid. At any rate, most of the problems of clinical glaucoma do not concern these exceptions but rather the two large groups of cases in which glaucoma is due to mechanical obstruction and the failure of osmotic forces.

3. Obstructive types of glaucoma which lend support to the idea of circulation of the aqueous are as follows:

(*a*) Dislocation of the Crystalline Lens into the Anterior Chamber: Cases of congenital dislocation of the lens, in which the involved eye is normal until the lens becomes dislocated into the anterior chamber, are not uncommon. Priestley Smith [12] and Friedenwald [9] have described such cases. In Friedenwald's case, the small lens acted as a ball valve in the pupillary opening. The iris bulged forward gradually, and the anterior chamber became shallower. The intraocular tension did not rise until the iris had reached the cornea, between one half and three quarters of an hour afterward. Subsequent estimation of the volume of the anterior chamber of the other eye and determination of the volume of

10. Kronfeld, P. C.: Introduction to Ophthalmology, Springfield, Ill., Charles C. Thomas, Publisher, 1938, p. 174.

11. Troncoso, M. U.: The Physiologic Nature of the Schlemm Canal, Am. J. Ophth. **4**:321, 1921.

12. Smith, P.: Movement of Intraocular Fluid as Taught by Theodor Leber, Brit. J. Ophth. **11**:263, 1927.

the dislocated lens permitted calculation of the approximate amount of fluid which left the anterior chamber during that period. This value indicated the flow of aqueous to be approximately 1.5 to 2.5 cu. mm. per minute.

(*b*) Glaucoma Following Seclusion of the Pupil, as in Iris Bombée: The iris acts as a diaphragm which is bulged forward, indicating that some of the fluid in front of it has passed out of the anterior chamber while more has formed behind it. When the iris is incised in cases in which the angle is still open, the tension returns to normal, indicating a resumption of circulation.

(*c*) Glaucoma Following a Perforating Corneal Wound: This type has long been known to be associated with obstruction of the chamber angle by iris.

(*d*) Dilatation Glaucoma: In certain persons, especially in the older age group, dilatation of the pupil gives rise immediately to a form of acute glaucoma without congestion. This is, of course, the same condition that occurs in some persons after a period in a darkened motion picture theater. If this form of acute glaucoma does not subside spontaneously or under treatment, it may enter a congestive phase. A study was made [13] to determine the ultimate cause of this mydriatic form of acute glaucoma. Into the conjunctival cul-de-sacs of 13 nonglaucomatous eyes of patients with unilateral acute glaucoma and of 7 acutely glaucomatous eyes which had become normalized with miotics, 1 or more drops of solution of 2 per cent eucatropine hydrochloride, 1 per cent paredrine hydrobromide ophthalmic or 2 per cent homatropine hydrobromide or combinations of these drugs was instilled. The first provocative dilations were done with the eucatropine solution, without positive results, but by increasing the amount of dilatation, with the paredrine or the homatropine solution or both, positive results were obtained. In 1 case, in which paredrine was ineffective, the homatropine solution increased the amount of dilatation and gave a positive result. In a total of 7 of the 20 provoked eyes (table 1), the tension rose to a high level and afterward was quickly reduced to normal by the use of a miotic drug. In all but 1 of the eyes examined, the chamber-angle depth was measured gonioscopically before, during and after dilatation. In each of the eyes in which results were positive, the angle was open before dilatation but closed by the forward position of the iris at the end of dilatation. In the eyes with negative results the angle remained patent, though narrowed. Photographic measurements of the depth of the anterior chamber in this series of eyes revealed that in all the chamber was shallow and that the use of the various

13. Sugar, H. S.: The Mechanical Factors in the Etiology of Acute Glaucoma, Am. J. Ophth. **24**:851, 1941.

drugs did not change its axial depth. It was concluded that this form of glaucoma results from obstruction of the chamber angle by the thickened iris in eyes with a shallow chamber and angle. The rapid rise of tension following such obstruction and its rapid reduction when miotics are instilled indicate that a through and through circulation must be present.

(*e*) Acute Glaucoma: In a previous paper [14] the gonioscopic appearance in a series of 445 eyes with so-called primary glaucoma not treated

TABLE 1.—*Provocative Pupillary Dilatation to Precipitate Acute Glaucoma*

Case Number and Eye	Drug *	Maximum Pupillary Dilatation, Mm.	Time to Develop Tension, Hr.	Tension Before Dilatation (Schiøtz) Mm.	Tension After Dilatation, Mm.	Depth of Anterior Chamber, Mm.	Depth of Anterior Chamber of Other Eye, Mm.
2 R	HA	7	3	17	17	1.18	0.78
9 L	P, HA	4.5	3¼	19.5	21	0.97	0.97
10 L	P, HA	4.0	2½	18	24		
11 R	E, P, HA	5.5	4	18	18	1.40	1.30
12 R	HA	7.0	4½	23	23	0.88	0.72
15 L	E	5.5	1¼	18	18	0.51	
Same	P	6.5	3¼	18	60	0.51	
16 R	P, HA	4.5	2¾	21	21	1.58	
17 L	E	5.0	1	19.5	19.5	1.03	
Same	HA	5.5	3	21	21	1.03	
18 L	E	4.5	½	28	60	1.55	1.30
19 (OP)L	E	4.5	2	21	20	1.36	1.40
Same	HA	6.0	2	24	60	1.36	1.40
19 R	HA	6.0	2	24	26	1.40	1.36
22 L	E	4.5	⅔	26	57	1.13	1.30
23 L	E, P, HA	6.5	4½	23	26	0.92	
29 R	E	...	3	15	43	1.18	1.40
29 L	P, HA	7.0	2¾	15.5	20	1.40	1.18
31 (OP)R	E	4.0	2	19.5	24.5	1.55	
Same	P, HA	5.0	2¼	23	57	1.55	
32 L	P, HA	4.5	3½	21	21	1.53	1.47
35 R	P	5.0	2½	19.5	24.5		
37 L	P	4.5	2	15	15	0.92	
Same	HA	6.5	3¾	15	52	0.92	
45 R	E	7.0	1½	13.5	24.5	1.65	1.50
Same	HA	7.0	3	21	24.5	1.65	1.50

* HA indicates homatropine hydrobromide, P paredrine hydrobromide ophthalmic and E eucatropine hydrochloride.

by operation was described to indicate that in a portion of them, those with acute glaucoma, the difficulty was mechanical in nature. A total of 68 eyes with acute glaucoma were included in the series. In all the chamber was shallow. In 13 eyes the tension was normalized within one to three days after the onset of the attack. In 9 of the 13 the angle was deep enough to be seen gonioscopically. It was entirely open in 6 and partly open in 3. The open angles were all in eyes in which the attack had been relieved within twenty-four hours of its onset. In the 3

14. Sugar, H. S.: Gonioscopy and Glaucoma, Arch. Ophth. **25**:674 (April) 1941.

in which the angle was partly open, the attack had lasted forty-eight to seventy-two hours. One of these had an open area involving about 25 degrees of the circumference of the angle. In this eye the tension was reduced to normal with miotics but subsequently rose again. In all the other eyes with acute glaucoma not treated by operation, the angle was not visible because of epithelial edema. However, it may be inferred from the appearance of the chamber angles after iridectomy that they were all closed before operation, since, except in the eyes in which filtering cicatrices formed, the tension became normal only when a portion of the chamber angle was visibly opened. In 6 eyes, in which the angle was visible after unsuccessful iridectomy, the angle remained completely closed, and even the root of the iris at the area of operation was plastered against the angle wall.

This group of cases indicates that mechanical closure of the chamber angle obstructs the circulation and gives rise to acute glaucoma. Its relief by partially opening the chamber angle by miotics or surgically suggests the presence of a continuous circulation of aqueous. These observations have recently been corroborated by Bangerter and Goldmann,[14a] who found the angle completely closed during the attack in 39 cases of acute glaucoma. In the cases in which the tension was reduced by miotics, the angle was seen to open, remaining, however, very narrow.

(*f*) Glaucoma Associated with Intumescent Cataract: The occurrence of acute glaucoma resulting from intumescence of a cataractous lens is not uncommon. This condition is usually unilateral and indicates that shallowing of the anterior chamber by the increased lens volume sets the stage for the same mechanical obstruction to the aqueous circulation which is found in acute glaucoma. In 2 instances, acute glaucoma has been precipitated by mydriatics in an eye with intumescent cataract. In 1 (case 47 [13]) the patient had a pale eye with a tension of 60 mm. of mercury (Schiøtz) when first seen. Miotics reduced the tension to normal within two hours. Subsequently, at the time of operation for removal of the lens, another attack of high ocular tension was induced by the instillation of cocaine for anesthesia. Miotics reduced the tension to normal within thirty minutes. In the second case, that of a 70 year old glaucoma-free patient with intumescent cataract, provocative dilatation of the pupil with 1 drop of 1 per cent paredrine hydrobromide ophthalmic solution increased the tension from 17.5 to 48 mm. in forty minutes. The pupil had dilated from 4 to 8 mm. The patient had previously been known to have 14 D. of myopia. The tension was rapidly reduced to normal with a drop of 2 per cent pilocarpine nitrate solution.

14a. Bangerter, A., and Goldmann, H.: Kammerwinkelstudien beim primären Glaukom, Ophthalmologica **102**:321, 1941.

The rapid rise in tension on mydriasis and its rapid fall after the use of miotics indicate that with this type of glaucoma too one is dealing with a mechanical obstruction to a continuous circulation of the aqueous.

(*g*) Aphakic Obstructive Glaucoma Following an Operation for Cataract: The evidence for the causation of this form of glaucoma is the most important clinical support for the theory of through and through circulation of the aqueous. Histologic and clinical evidence led Czermak [15] in 1898 to conclude that this type of glaucoma was due to prolonged absence of the anterior chamber as a result of delayed wound closure. He found the iris adherent to the periphery of the cornea histologically.

In 1940 I made a preliminary gonioscopic report [16] on a series of 30 cases of glaucoma following operation for cataract and in 1941 followed this with a complete study [14] of 52 eyes. All the patients were known to have been nonglaucomatous prior to the surgical treatment of cataract. Cases in which uveitis was present or those in which the interval between the operation for cataract and the development of ocular hypertension was over a year were excluded. Of the 52 eyes, all but 2 had peripheral anterior synechias extending at least up to the third of the trabecula nearest the cornea and usually up to the ring of Schwalbe. In the 2 exceptions, in which only small areas remained open, the tension returned to normal with miotics. It should be remembered that the anterior third of the trabecula does not usually contain trabecular spaces; so there is evidence that obstruction of the trabecular spaces by iris causes this form of glaucoma. As mentioned in the preliminary report, the history in many of the cases indicated a prolonged postoperative period during which the anterior chamber was collapsed, the collapse being associated in some instances with recognized choroidal detachment or prolapse of the iris. Kronfeld and Grossmann [17] have corroborated these findings.

(*h*) Glaucoma Capsulare: While the relation between capsular exfoliation and glaucoma capsulare has not been proved beyond any doubt, there is sufficient evidence to warrant inclusion of glaucoma capsulare here. Of 643 cases of capsular exfoliation reported in the literature up to 1940,[18] glaucoma was definitely shown to be present in

15. Czermak, W.: Die augenärztliche Operationen, Vienna, C. Gerolds Sohn, 1898.

16. Sugar, H. S.: Concerning the Chamber Angle: I. Gonioscopy, Am. J. Ophth. **23**:853, 1940.

17. Kronfeld, P. C., and Grossmann, E. E.: The Relation of the Gonioscopic Findings to the Incidence of Secondary Glaucoma in Operative Aphakia, Tr. Am. Acad. Ophth. (1940) **45**:184, 1941.

18. References on glaucoma capsulare statistics, in Gradle, H. S., and Sugar, H. S.: Concerning the Chamber Angle: II. Exfoliation of the Zonular Lamella and Glaucoma Capsulare, Am. J. Ophth. **23**:982, 1940.

355. Vogt found glaucoma in 75 per cent of 45 cases of exfoliation, Busacca in 90 per cent of 30, Trants in 33 per cent of 42, Baumgart in 63 per cent of 43, Garron in 80 per cent of 10 and Pletneva in 71 per cent of 31. Grzedzielski reported glaucoma in 90 per cent of 156 collected cases of exfoliation. Of his own series of 17, glaucoma was present in 12. Irvine found 25 cases of glaucoma among 40 of exfoliation. Gradle and I found glaucoma in 72 per cent of 82 eyes with exfoliation. The biomicroscopic and the gonioscopic picture in capsular exfoliation and in glaucoma capsulare are the same. The characteristic gonioscopic finding of marked pigment deposition in the trabecular spaces, together with the less frequently visible particles of capsular material or pigment or both, hinders access of the aqueous to the wall of Schlemm's canal. That this is probably true is further indicated by the fact that after removal of the cataractous lens, the intraocular tension is not usually much affected.[14] Of 12 eyes from which the lens was removed for glaucoma capsulare, all continued to have ocular hypertension of a degree similar to or slightly less severe than that present before operation. Two of the 12 required antiglaucoma surgical treatment, while the others required the use of miotics for control of the tension. This group provides suggestive evidence that interference with access of the aqueous to the wall of Schlemm's canal obstructs the circulation of aqueous, resulting in glaucoma.

C. *The Effect of Glaucoma Operations.*—The reduction of intraocular tension by the various surgical procedures to establish substitute channels for the drainage of aqueous indicates that a through and through circulation of the aqueous probably exists. The filtering operations, including the Elliot trephining, the La Grange sclerectomy and the iris inclusion operations (iridencleisis and iridotasis) all depend on subconjunctival drainage of the aqueous, as is evidenced by the formation of edematous blebs and sometimes even of tiny fistulas, which are made evident by the instillation of fluorescein over the bleb. Slit lamp examination of the aqueous flare when such formations are present reveals no evidence of a significant increase in the aqueous protein, which would be expected if plasmoid aqueous were present. In a study of trephined eyes in which the trephine opening was visible,[14] 52 were found to have normal tension. In 12 the tension was controlled with miotics, and in 22 it was uncontrolled (table 2). These were observed gonioscopically to determine the relation of success or failure of the trephining operation to the patency of the opening. In 28 per cent of the normalized eyes, the trephine hole was partly filled by iris, ciliary processes, lens or sclera. In 83 per cent of those in which the tension was controlled with miotics, the trephine opening was partly filled with the same tissues. In addition, 1 contained connective tissue. In 20 (90 per cent) of 22 eyes in which

the tension was uncontrolled, the opening was completely plugged by iris, ciliary processes or lens. In the 2 remaining eyes (tension uncontrolled), there was a patent trephine opening, but a scarred, nonfiltering conjunctival covering was present.

Even more clear is the evidence obtained from the effect of cyclodialysis in reducing ocular hypertension, both in simple glaucoma and in glaucoma following operation for cataract. In a total of 52 eyes with simple glaucoma and 56 with glaucoma following an operation for cataract,[14] an "all or none" relation was established between the success of the operation and the formation of a communication between the anterior chamber and the supraciliary space. If a patent cleft was formed, the tension was always reduced to normal. If no cleft was formed, the ocular hypertension recurred. So absolute was this relation that if an eye operated on was examined a week or two postoperatively and no cleft found, the return of the ocular hypertension within five or six weeks

TABLE 2.—*Relation Between Tension Control and Patency of Trephine Opening*

Tension	Visibility of Trephine Opening		Visible Trephine Openings with Partial or Complete Plugging
	Not Seen	Seen	
Normal, 101	49	52	15 partly filled (28%)
Controlled with mioties, 22	10	12	10 partly filled (83%)
Uncontrolled, 31	9	22	20 completely plugged (90%)
Total, 154	68	86	45

could be correctly prognosticated even though the tension at the time of examination was normal. Especially in the eyes with glaucoma following operation for cataract in which the chamber angle was blocked by iris, the operation succeeded in permitting access of the aqueous to the blood vessels of the ciliary body, thus permitting its reabsorption. As a matter of fact, this procedure is the perfect operation for glaucoma, since it substitutes the osmotic effect of the contents of the many vessels of the ciliary body for the osmotic effect of the contents of Schlemm's canal.

III. REABSORPTION OF THE AQUEOUS

Since the work of Leber, the canal of Schlemm has been rather generally accepted as the chief locus of reabsorption of aqueous. The evidence has been phylogenetic, experimental and clinical.

A. *Phylogenetic Evidence.*—Although providing only suggestive evidence, a comparison of the mode of reabsorption of aqueous in man with that in the other members of the mammalian series is interesting. Animals below primates do not have any canal of Schlemm, nor is their

ciliary muscle as well developed as is that of primates. The absorption of fluid apparently takes place through the many thin-walled blood vessels in the region of the angle. In primates the function of accommodation has made changes in space necessary, so that the ciliary muscle assumes greater size. Schlemm's canal appears to have assumed the function of the many small blood vessels. That it should exercise this function would require afferent vessels in addition to efferent ones. That it has such vessels has been shown by Friedenwald.[19]

B. *Experimental Evidence.*—1. If a dye or particulate matter is injected into the anterior chamber of an animal eye, the path of exit from the eye can be observed. Seidel [20] found that these substances, up to a certain size, when injected into the anterior chamber of a rabbit's eye after part of the aqueous had been withdrawn found their way into the episcleral vessels at normal intraocular pressures. His obvious conclusion was that the ultimate outflow of fluid from the eye is to these vessels.

2. Friedenwald has shown [4] that if the intraocular pressure in dogs is raised 3 to 10 mm. above normal artificially, the rate of absorption of the aqueous may be increased to five or ten times the normal. If such an amount were leaving through the cornea, in accordance with Ridley's [21] work, which showed that measurable volumes of water may be forced through the cornea under moderate pressure, it would be grossly visible. If any fraction were absorbed behind the iris, the anterior chamber would increase in depth, and the iris would be dislocated backward. But Friedenwald found no evidence of any such change in the depth of the anterior chamber. When dye (potassium ferrocyanide and iron ammonium citrate) was added to the fluid entering the anterior chamber, none penetrated into the posterior chamber (as shown by removing the eye and fixing it in acid formaldelyde, thus precipitating prussian blue), but the anterior chamber and surrounding tissue were deeply stained; so it was evident that absorption took place in the anterior chamber, from the iris, or in Schlemm's canal or in both. Kronfeld [22] and Friedenwald and Pierce [23] have shown that the iris vessels may act as simple semi-

19. Friedenwald, J. S.: Circulation of the Aqueous: V. Mechanism of Schlemm's Canal, Arch. Ophth. **16**:65 (July) 1936.

20. Seidel, E.: Weitere experimentelle Untersuchungen über die Quelle und den Verlauf der intraokularen Saftströmung, Arch. f. Ophth. **104**:357, 1921; **108**: 420, 1922.

21. Ridley, F.: Intraocular Pressure and Drainage of Aqueous Humor, Brit. J. Exper. Path. **11**:217, 1930.

22. Kronfeld, P.: Absorption from Anterior Chamber, Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **49**:26, 1932.

23. Friedenwald, J. S., and Pierce, H. F.: Circulation of the Aqueous: III. The Reabsorption of Crystalloids, Arch. Ophth. **10**:449 (Oct.) 1933.

permeable membranes between the blood and the aqueous. By producing vasodilatation of the iris by irritating the cornea with weak ammonia, Friedenwald found an increase in absorption of the aqueous. He held that since congestion would raise the pressure within the iris capillaries, fluid should leave the iris vessels instead of passing into them and that the canal of Schlemm therefore was the main pressure-regulating mechanism. This flow of fluid from the iris vessels with vasocongestion takes place when the iris is inflamed to such an extent that considerable serum proteins appear in the aqueous. A decrease in the difference in osmotic pressure between the blood and the aqueous then tends to hinder reabsorption and leads to increased intraocular pressure. This is what is found in severe anterior uveitis, but more frequently the tension is found diminished for a reason which has not been taken into account heretofore. It should be remembered that the iris capillaries, like the kidney glomeruli and the capillaries of other tissues, are not all functioning at the same time. Thus, by reflex vasodilation alone, one increases the surface area of capillary walls tremendously, the increase leading to increased osmotic absorption. As long as the increased osmotic surface overbalances the slightly increased protein in the aqueous, the tension should decrease, but when the toxic factor is such that the vascular permeability is markedly increased, the reverse is true and the intraocular tension rises because of the diminished difference in osmotic pressure.

The action of the various drugs instilled into the conjunctival cul-de-sac is accountable in a similar manner. Pilocarpine, acetylbetamethylcholine, physostigmine and carbaminoylcholine chloride have been shown [24] to increase the vascular permeability but at the same time cause vasodilatation, thus producing a pronounced increase in the capillary surface. Atropine, on the other hand, has been shown to decrease the vascular permeability and causes vasoconstriction, thereby decreasing the total capillary surface. With these drugs it is undoubtedly true that the effect on the surface area of the capillary walls is the more important factor. One must consider, of course, that the factor causing vasodilatation in the iris is acting on the afferent vessels to Schlemm's canal, increasing the flow of serum through the canal. From this evidence and that discussed heretofore regarding obstructive glaucoma, it is evident that both the iris and Schlemm's canal, particularly the latter, are the loci of reabsorption of aqueous.

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24. Swan, K. C., and Hart, W. M.: A Comparative Study of the Effects of Metholyl, Doryl, Eserine, Pilocarpine, Atropine, and Epinephrine on the Blood-Aqueous Barrier, Am. J. Ophth. **23**:1311, 1940. Adler, F. H., and Landis, E. M.: Studies on the Protein Content of Aqueous Humor, Arch. Ophth. **54**:265, 1925. Adler, F. H.: The Action of Atropine in Ocular Inflammations, ibid. **55**:484, 1926.

3. It has been shown by Friedenwald [25] that the canal of Schlemm contains plasma and few erythrocytes. The afferent vessels to the canal have an internal diameter of 5 to 10 microns (Friedenwald [26]), thus accounting for the paucity of red cells. The efferent vessels from the canal are known to have a hydrostatic pressure of 2 to 3 mm. of mercury above the intraocular pressure (Duke-Elder [27]), so that the existence of any direct communication between the trabecular spaces and Schlemm's canal is physiologically impossible; otherwise, the contents of the canal would flow toward the aqueous. If the canal contains plasma, which acts by osmosis, attracting water from the anterior chamber, becoming diluted and entering the venous system, the intraocular tension will depend largely on the rate of flow of plasma through the afferent vessels. Any nervous or other factor that would increase or decrease the size of the lumens of the afferent vessels would increase or decrease the rate of absorption of aqueous. Thus the work of Friedenwald, in suggesting that arteriosclerosis of the afferent vessels may well be a factor in causing increased ocular tension, has great importance.

C. *Clinical Evidence.*—A large part of the clinical evidence for the reabsorption of aqueous has been discussed in the section on the circulation of the aqueous. One bit of evidence corroborating the work of Friedenwald and Scholz regarding the contents of the canal of Schlemm is the appearance of blood in the canal during gonioscopic examination.[14] Pressure on the contact glass occasionally causes a pink zone of diluted blood to become visible in a segment of the canal's circumference in a normal eye. The zone is rather frequently seen in inflammatory conditions and immediately after goniotomy. It has been seen to disappear and reappear quickly without ever entering into the anterior chamber. This fact lends support to the view that there are no direct communications between the trabecular spaces and the canal.

The recent work of Ascher [28] on the "aqueous veins" which are observable biomicroscopically in the limbal and the paralimbal region of the human eye is further evidence for a through and through circulation, with reabsorption largely through Schlemm's canal. This work also explains why pressure of a gonioscopic contact glass on the conjunctival vessels may cause a backflow of blood into Schlemm's canal, as previously described.

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25. Friedenwald, J. S.: Perspectives in Glaucoma Research, Arch. Ophth. **24**:107 (July) 1940.

26. Friedenwald, J. S.: Circulation of Aqueous: V. Mechanism of Schlemm's Canal, Arch. Ophth. **16**:65 (July) 1936.

27. Duke-Elder, W. S.: The Ocular Circulation, Brit. J. Ophth. **10**:513, 1926.

28. Ascher, K. W.: Aqueous Veins, Am. J. Ophth. **25**:31, 1942.

Further suggestive evidence for the importance of arteriosclerosis of the afferent vessels to Schlemm's canal as a factor in increasing ocular tension is derived from a study [29] of 9 patients with unilateral occlusion of the central retinal vein or its tributaries (table 3). One of the patients had glaucoma simplex in one eye and hemorrhagic glaucoma in the eye with the retinal venous occlusion. Two had hemorrhagic glaucoma in the eye with the venous occlusion, the other eye remaining normal. Of the other 6, 5 had glaucoma simplex in the eye with the venous occlusion and 1 had glaucoma simplex in both eyes.

A study of their cases indicated that all had a common basic condition, namely angiosclerosis. The retinal sclerosis led to venous occlu-

TABLE 3.—*Data on 9 Cases of Unilateral Retinal Venous Occlusion*

Case	Highest Preoperative Tension (Mm. Hg Schiøtz)		Central or Tributary Vein Involved
	Right Eye	Left Eye	
1.....	43 (glaucoma simplex)	42 (glaucoma simplex)	Left tributary vein
2.....	44 (glaucoma simplex)	Normal	Left tributary vein
3.....	30.5 (glaucoma simplex)	Normal	Left central vein; incomplete
4.....	28	37 (glaucoma simplex)	Right tributary vein
5.....	82 (hemorrhagic glaucoma)	32 (glaucoma simplex)	Right central vein; complete
6.....	30.5 (only once)	33.5 (glaucoma simplex)	Right central vein; incomplete
7.....	20	41 (glaucoma simplex)	Right tributary vein
8.....	23	82 (hemorrhagic glaucoma)	Left central vein; complete
9.....	60 (hemorrhagic glaucoma)	Normal	Right central vein; complete

sion, while sclerosis in the afferent vessels to Schlemm's canal could have been the cause for the glaucoma simplex. In the eyes with venous occlusion, the occurrence of hemorrhagic glaucoma undoubtedly resulted from the toxic effect of repeated large intraocular hemorrhages.

IV. CLASSIFICATION OF GLAUCOMA

If aqueous continuously enters the eye and is reabsorbed, glaucoma will result from interference with any portion of the path of its circulation. Thus there must be several possible places where this interference may take place and consequently several etiologically different forms of

29. Sugar, H. S.: The Place of Hemorrhagic Glaucoma in the Etiologic Classification of Glaucoma, Arch. Ophth., to be published.

glaucoma. The classification of glaucoma which is in ordinary use today is a clinical one. It divides glaucoma into primary (idiopathic) glaucoma and secondary glaucoma (due to some known precipitating factor). Primary glaucoma is subdivided into three types, namely acute congestive, chronic congestive and chronic noncongestive, or simple, glaucoma. Gradle prefers the terms compensated and incompensated instead of congestive and noncongestive. Duke-Elder,[30] in speaking of so-called primary glaucoma, stated that

> although from the etiological point of view it is unjustifiable, it is convenient from the clinical point of view to divide cases of glaucoma into two main groups, each of which presents a completely different clinical picture so that they appear to be separate and unrelated diseases—simple and congestive. . . . The differentiation rests upon the adaptability of the circulation to accommodate itself to the tension. . . .

This idea, that so-called primary glaucoma is a single disease entity with several related subtypes, is an idea which has held back progress in the understanding of glaucoma for many years. In addition, the clinical classification often fails. Many patients with a history and symptoms suggesting a classification of chronic congestive glaucoma have never been found to have congestion. Similarly, patients with late simple, or noncongestive, glaucoma occasionally come under observation with all the evidences of acute vascular congestion. And patients with early acute glaucoma following pupillary dilation usually show no evidence of congestion, so that they cannot be properly classified as having acute congestive glaucoma. Both Barkan and I have discussed the fallacy of considering vascular congestion or lack of it as criteria in the classification of glaucoma.

Raeder [31] in 1923 first introduced a reasonable subdivision of so-called primary glaucoma into two types, based on the depth of the anterior chamber, namely shallow chamber glaucoma and normal or deep chamber glaucoma. Barkan [32] and I [13] have since advocated a similar classification, referring more specifically to the depth of the angle.

Barkan subdivided so-called primary glaucoma into trabecular (or wide angle) glaucoma and narrow angle (or iris block) glaucoma. He stated the belief that the trabecular type corresponds to glaucoma simplex

30. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1941, vol. 3, p. 3364.

31. Raeder, J. G.: Untersuchungen über die Lage und Dicke der Lense im menschlichen Auge bei physiologischen und pathologischen Zuständen nach einer neuen Methode gemessen: II. Die Lage der Lense bei glaukomatösen Zuständen, Arch. f. Ophth. **112**:29, 1923.

32. Barkan, O.: Choice of Operations in Glaucoma, Am. J. Ophth. **24**:768, 1941.

and includes "pigment glaucoma," "glaucoma senile," glaucoma capsulare and glaucoma with a normal-appearing angle, which is probably "due mainly to disturbances in secretion, either in amount or in composition, or to a relative reduction in permeability of the trabecula on a congenital basis." He stated that narrow angle glaucoma is the "pathologic entity that underlies most cases of so-called chronic congestive glaucoma" and from which attacks of acute glaucoma result. The term trabecular glaucoma is in my opinion not correct, since in most cases the condition appears to be what Barkan called "glaucoma senile" and in some is probably due to arteriosclerosis of the afferent vessels to Schlemm's canal (Friedenwald), which does not involve the trabecula at all.

One other point which I wish to make about Barkan's classification is that he divided the narrow angle type, corresponding to so-called chronic congestive glaucoma, into an early form, without synechias, and a late form, with synechias. From gonioscopic and clinical observation it is evident, however, that synechias never form in shallow angle glaucoma without the presence of acute episodes of congestion, so that the late form of so-called chronic congestive glaucoma must follow congestive episodes and should be classified under acute glaucoma. In a previous paper,[13] it was pointed out that in the majority of cases acute glaucoma begins without vascular congestion, but, after a varying period, ranging from several hours to several days, the eye becomes red and painful because its vascular system can no longer tolerate the acute ocular hypertension. During the noncongestive phase the disease entity is still actually acute glaucoma. If episodes of acute glaucoma in the noncongestive phase recur repeatedly and the condition subsides without entering the congestive phase or after entering it for only a short time, the condition is considered so-called chronic congestive glaucoma, but it is actually a recurrent form of ordinary acute glaucoma. If allowed to recur often enough, it will always enter the congestive phase. Thus, the classification should not differentiate early and late narrow angle glaucoma from acute glaucoma. To illustrate the differences between "chronic congestive glaucoma"—acute glaucoma—and simple glaucoma, a summary of the clinical pictures will not be irrelevant.

Clinical Picture of Acute Glaucoma: The actual onset of the noncongestive phase of acute glaucoma is hardly noticed by the patient. Blurring of vision in prepresbyopia and in early presbyopia may be present as a result of interference with the function of the ciliary muscles. Occasionally the onset is associated with colored halos. Irritation of the conjunctiva and slight pain in the head or in the eye may be present. Usually the symptoms last about a half to two or three hours and subside entirely, only to recur again at varying intervals, becoming more frequent and lasting longer as time goes on, each attack leaving anatomic conditions more favorable for further attacks. The circumcorneal injection, if any, associated with these episodes is slight.

Occasionally the patient relates that he can relieve the symptoms by the use of hot or cold applications, by looking at a bright light for several minutes or by sleep.

Ultimately, one of the mild episodes will persist longer than usual, and suddenly the patient will experience marked diminution in vision, photopsia, swelling and redness of the conjunctiva and pain in the head and the eyes often so severe as to cause nausea and vomiting. The sudden change in symptoms often awakens the patient from sleep and occurs without any precipitating factor, it being an aggravation of the previous mild symptoms induced by a break in the vascular equilibrium of the eye as a result of the continued high intraocular pressure. Probably an accumulation of tissue metabolites within the eye when drainage of the intraocular fluid is impeded causes the vascular decompensation. At any rate, the sudden aggravation of symptoms is attributable to the combination of high intraocular pressure and increased permeability of the vascular walls.

In some cases the first mild noncongestive episode of acute glaucoma is followed by the congestive phase. Of course, if treated early with miotics, even the congestive phase subsides rapidly, and if the patient does not use miotics as a prophylactic measure it will likely recur, the disease passing again through the noncongestive phase. What has been previously called the prodromal stage of acute glaucoma is in reality the noncongestive phase of the disease.

Objectively, the tension may not be different in the noncongestive and in the congestive phase. It is usually very high in the latter, since such factors as an increase in the protein content of the aqueous become effective in addition to the mechanical obstruction of the angle.

Shallowness of the anterior chamber is typical of this type of glaucoma, but the depth is not different from that in the eyes of patients without glaucoma who are predisposed to the disease. It has been shown also that the depth of the chamber does not decrease when the congestive phase is entered.

Vascular decompensation produces not only chemosis of the conjunctiva but edema of all the ocular tissues. The corneal epithelium is so involved that details in the fundus are obscured. Blebs and vesicles appear on the cornea. The cornea loses its sensitivity. In the noncongestive stage, even in the presence of very high tension, the cornea is not edematous, and arterial pulsation is easily seen in the fundus.

The pupil is dilated in both phases of acute glaucoma but is irregular in the congestive phase. The dilatation when it is not in itself the actual etiologic factor in the onset of the disease is probably due to slight stretching of the eyeball and to the pressure effect on the nerves. In rabbits, if a needle is inserted into the anterior chamber and the pressure increased, the pupil dilates, and it contracts when the pressure is decreased. Barkan [33] suggested that the vertically oval shape of the pupil is due to anatomic narrowness of the angle above. Undoubtedly, in the congestive phase the blood supply to a few of the nerve fibers to the sphincter in affected irregularly, and irregularity of the pupil results.

The iris in the congestive phase becomes muddy and discolored. Some of the iris vessels become visibly distended. If the congestive phase persists any length of time, fine posterior synechias may form.

The nerve head in the noncongestive phase is normal. In the congestive phase, it is red but not excavated. If repeated attacks occur or if an attack persists, the disk becomes rather rapidly excavated.

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33. Barkan, O.: Glaucoma: Classification, Causes, and Surgical Control, Am. J. Ophth. **21**:1099, 1938.

Biomicroscopy reveals abnormalities only in the congestive phase. Edema of the epithelium, blebs and vesicles are seen. The contents of the anterior chamber and the vessels of the iris are difficult to see clearly in this phase. Chemical studies are of no etiologic significance but show only the results of the vascular changes.

In the noncongestive phase, gonioscopy reveals closure of the chamber angle. In the congestive phase, its closure must be presumed, since the cornea is too cloudy for visibility of the angle.

In a person in whom a congestive attack is relieved spontaneously or with miotics, floating particles of pigment, irregularity of the pupil, occasional fine posterior synechias and pigment on the posterior corneal surface are seen. Slight persistent pericorneal injection may be present. If a patient is seen for the first time after such an attack, the tension in the eye is usually below normal and an erroneous diagnosis of acute iritis may be made.

When the congestive phase of acute glaucoma has been allowed to exist without treatment, the eye eventually becomes blind and enters the stage common to all types of glaucoma, called absolute glaucoma. The eye remains injected, the episcleral veins remain dilated, vesicles form on the cornea and the iris remains muddy. Pain persists. Gradually, the vascular system adjusts itself somewhat, and the eye often becomes less painful.

Clinical Picture of Glaucoma Simplex: The usual patient with early glaucoma simplex has no symptoms until changes in the visual fields bring the condition to his attention. Occasionally some fogginess of vision and diminished accommodation bring him to the oculist. Occasionally colored halos around lights are complained of. In the late stages he complains of night blindness, contraction of the visual fields or even interference with macular vision.

Objectively, the ocular findings in simple glaucoma are gradual in appearance. The earliest are a slight ocular hypertension and changes in the pericecal visual field, usually manifested as a vertical increase in the size of the blindspot. As the disease progresses the field changes increase slowly, so that various characteristic changes, such as Bjerrum's sign and Roenne's step, occur. Excavation of the optic disk begins at the temporal side of the disk. As the disease progresses, the excavation of the disk increases concurrently with concentric contraction of the field, until only a central zone about 10 degrees in diameter remains.

If allowed to continue untreated, the tension usually remains between 30 and 45 mm. of mercury (Schiøtz), and the central field is finally lost. In this state of absolute glaucoma, the eye may remain painless and pale or may after a considerable time suddenly enter a congestive state, in which the conjunctival vessels become injected, the eye painful and the tension high. In fact, the onset and the symptoms may be the same as in an eye with acute glaucoma which has entered the congestive phase.

Gonioscopically, the chamber angle is normal in depth in simple glaucoma,[33a] although one occasionally finds cases of simple glaucoma in which the chamber and the angle are relatively shallow. The shallowness is coincidental, since the factors leading to relative shallowing of the chamber are present in persons of the age group affected. In the late stages of simple glaucoma which enters a congestive phase as a result of vascular decompensation, peripheral anterior synechias form.

33a. This observation has recently been corroborated by Bangerter and Goldmann in 40 cases of simple glaucoma.[14a]

The slit lamp findings in simple glaucoma are entirely negative except in the late stages when congestive episodes have occurred. Then the evidences of inflammatory and atrophic changes are seen.

The diagnosis of simple glaucoma depends on tonometric and perimetric studies. The provocative tests [34] are usually of little help in the early stages except that of puncture of the anterior chamber (Kronfeld [35]). The tension curve often helps. In more advanced stages the diagnosis is made on the basis of the visual fields, the tension and the appearance of the optic disk.

The fact that even after surgical treatment in late stages the progress of the optic nerve atrophy is not halted indicates that operation should be done at the first indication of any field changes in simple glaucoma, even though medical treatment is apparently successful in controlling the tension.

Part of the difficulty in accepting a classification based on the depth of the chamber and the angle is due to the error of considering that the patient with simple glaucoma has a shallow chamber. Friedenwald [36] in his earliest paper on the circulation of the aqueous stated that "chronic simple glaucoma remains as yet the hub of our mystery, and must remain so until an adequate explanation of the shallow anterior chamber in this condition has been supplied." That the depth of the chamber in the patient with simple glaucoma does not vary from the normal was first pointed out by Rosengren,[37] who used a highly accurate optical method of measurement. Gradle and I [37a] made similar observations.

The patient with true acute glaucoma, on the other hand, always has a shallow anterior chamber and angle. The factors which produce such shallowness are the ultimate etiologic factors in the occurrence of acute glaucoma. The factors which influence the depth of the chamber may be divided into two groups, anatomic and physiologic. The anatomic group includes (1) errors of refraction, (2) continuous growth of the lens throughout life, (3) the size of the eye and (4) the thickness of the iris. The physiologic group includes (1) accommodation, (2) pupillary dilatation and (3) congestion of the ciliary body.

A. *Anatomic Factors.*—1. Errors of Refraction: It has long been known that the large majority of eyes with acute glaucoma are hyperopic.

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34. Sugar, H. S.: Provocative Tests in Suspected Glaucoma, in Compensated Glaucoma, Omaha, Neb., American Academy of Ophthalmology and Otolaryngology, 1941.

35. Kronfeld, P. C.: Anterior Chamber Punctures in Relation to Intra-Ocular Tension, Arch. Ophth. **9**:801 (May) 1933.

36. Friedenwald, J. S., and Pierce, H. F.: The Circulation of the Aqueous, Bull. Johns Hopkins Hosp. **49**:259, 1931.

37. Rosengren, B.: Studien über die Tiefe der vorderen Augenkammer, Acta ophth. **8**:99, 1930; **9**:103, 1931.

37a. Gradle, H. S., and Sugar, H. S.: Concerning the Chamber Angle: III. A Clinical Method of Goniometry, Am. J. Ophth. **23**:1135, 1940.

Fuchs [38] stated that "a disposition toward inflammatory glaucoma appears to belong principally to hypermetropic eyes, whereas strongly myopic eyes are to be regarded as having almost complete immunity against the disease." Two facts indicate the truth of this statement. First, gonioscopic observation indicates that in hyperopic eyes the iris root appears to be inserted farther forward on the anteromedial surface of the ciliary body, while in myopic eyes it is inserted correspondingly farther back. Second, in persons of the same age group, an analysis of the depth of the anterior chamber and of the refractive error indicates

TABLE 4.—*The Relation Between Chamber Depth and Refractive Error in Persons Between the Ages of 25 and 45 Years, Inclusive*

	Hyperopic Refractive Error				
Age	0 to 0.50 D., Mm.	0.75 to 1.00 D., Mm.	1.25 to 1.50 D., Mm.	1.75 to 2.50 D., Mm.	2.75 to 3.50 D., Mm.
25	3.55 (3)*	3.59 (8)	3.57 (5)		
26	3.79 (3)	3.39 (5)	3.36 (5)		
27	3.57 (4)				
28	3.38 (3)	3.48 (7)			
29	3.79 (2)	3.54 (3)	3.46 (3)	3.54 (2)	
30	3.80 (2)	3.63 (6)	3.12 (2)		
31	3.27 (6)	3.79 (6)	3.58 (2)		
32	3.43 (6)	3.36 (8)	3.16 (4)		
33	3.89 (2)	3.16 (2)	3.73 (2)		
34	4.15 (2)	3.71 (3)	3.22 (3)		
35	3.44 (7)	3.46 (5)	2.98 (3)	3.23 (1)	
36	3.85 (3)	3.60 (3)	3.38 (4)		
37	3.62 (2)	3.50 (2)	....	2.95 (2)	
38	3.44 (4)	3.61 (2)	3.20 (2)	3.51 (2)	
39	3.24 (4)	3.22 (7)	3.45 (2)		
40	3.42 (3)	3.32 (10)	3.07 (3)		
41	3.33 (7)	3.29 (6)	3.26 (3)		
42	3.49 (8)	3.48 (11)	3.50 (6)	2.83 (3)	
43	3.50 (6)	3.45 (7)	3.38 (10)	3.19 (3)	
44	3.38 (8)	3.44 (15)	3.32 (4)	3.09 (3)	2.91 (1)
45	3.45 (8)	3.37 (9)	3.26 (5)		
Average of above values	3.50	3.45	3.34	3.17	2.91

* Figures in parentheses indicate number of eyes in each group.

that there is a rather definite inverse relation between the two; i. e., the chamber depth decreases as the hyperopia increases. This conclusion was drawn from a study of a series of 191 hyperopic eyes in Rosengren's [37] accurately measured normal patients (table 4) and a series of 398 normal patients between the ages of 18 and 60 measured by me,[38a] using the method of measurement described elsewhere.[38b]

38. Fuchs, E.: Textbook of Ophthalmology, translated by A. Duane, ed. 4, Philadelphia, J. B. Lippincott Company, 1911, p. 472.

38a. Sugar, H. S.: The Anatomic Factors Which Influence the Depth of the Anterior Chamber, Am. J. Ophth., to be published.

38b. Sugar, H. S.: A Practical Method of Measuring the Depth of the Anterior Chamber, Am. J. Ophth., to be published.

2. Continuous Growth of the Lens Throughout Life: As lens fibers are added to the lens cortex, the dimensions of the lens continue to increase throughout life. The increase causes definite progressive shallowing of the chamber and the angle. The shallowness is ordinarily of little significance except when it reaches a marked degree. It is probable that in hyperopes in whom the chamber was originally relatively shallower than normal, the increased size of the lens is the chief factor in increasing the shallowness.

3. Size of the Eye: Priestley Smith [39] stated that the eyes of patients with glaucoma are, on the whole, smaller than normal. Although he did not distinguish between the various etiologic types of glaucoma, his studies indicate that mechanical factors associated with decreased ocular dimensions may be one of the factors in producing a relative disproportion between the increasing size of the lens and the surrounding sclerocorneal envelop.

4. Thickness of the Iris: Though it does not influence the axial depth of the anterior chamber, the peripheral depth is markedly affected by the thickness of the ciliary portion of the iris.

B. *Physiologic Factors.*—1. Accommodation: In persons of prepresbyopic age and to a much lesser extent in persons with early presbyopia, accommodation tends to decrease the depth of the angle.

This contradicts the previously held views of Grönholm [40] and Thomson,[41] who concluded that accommodation opens the chamber angle. I observed the effect of accommodation on the angle directly [13] by the following method: A gonioscopic contact lens was placed on one eye of a recumbent practically emmetropic, prepresbyopic person. He was asked to observe a printed card held about 12 inches (30 cm.) from the other eye. A 4.00 D. convex lens was placed in front of the reading eye and the angle of the lens-covered eye observed with the binocular microscope. When the reading lens was removed, a slight convergence movement was observed, followed after a short lag period by movement forward of the ciliary zone of the iris. Observations on normal persons indicated that the accommodative movement was strongest in young persons and decreased in amount as age advanced, becoming hardly perceptible in the late 40's and early 50's.

2. Pupillary Dilatation: By increasing the thickness of the iris tissue in the angle, pupillary dilatation tends to decrease the depth of

39. Smith, P.: The Pathology and Treatment of Glaucoma, London, J. & A. Churchill, 1891.

40. Grönholm, V.: Untersuchungen über den Einfluss der Pupillenweite, der Accommodation und der Convergenz auf die Tension glaucomatoser und normaler Augen, Arch. f. Augenh. **66**:346, 1910.

41. Thomson, A.: The Filtration Angle, Ophthalmoscope **9**:470, 1911.

the angle but is significant usually only when the angle is relatively shallow. The relation between the depth of the chamber and that of the angle, the size of the pupil and the thickness of the iris when the pupil is dilated is important in the mechanical blockage of the angle which leads to the type of acute glaucoma usually referred to as mydriatic glaucoma. This relation is the basis of certain of the provocative tests

TABLE 5.—*Suggested Etiologic Classification of Glaucoma*

1. Failure of osmotic forces (no mechanical closure of the chamber angle by iris)
   (*a*) Arteriosclerosis of afferent vessels to Schlemm's canal (Friedenwald); chronic simple glaucoma
   (*b*) Obstruction of the trabecular spaces
      (1) Glaucoma capsulare
      (2) Pigmentary obstruction—only when marked pigment deposit is present is present
      (3) Blocking of trabecular spaces by cellular debris in cases of iridocyclitis, active and healed
      (4) Blocking by tumor growth
   (*c*) Increased protein in aqueous—severe uveitis
   (*d*) Vascular changes in angle due to toxic effect of severe retinal-vitreous hemorrhage—hemorrhagic glaucoma (the angle is open early and closed by iris later)
      (1) Occlusion of central retinal vein
      (2) Diabetic rubeosis
2. Mechanical closure of the chamber angle by iris
   (*a*) Shallow angle glaucoma
      (1) Acute glaucoma, including the recurrent form, which was formerly called "chronic congestive glaucoma" (this type corresponds to the acute and chronic congestive glaucoma of the older classification)
      (2) Acute glaucoma due to intumescence of lens
      (3) Dislocation of lens—into anterior chamber
   (*b*) Glaucoma following operation for cataract—aphakic obstructive glaucoma (in this type the chamber is deep, the angle blocked)
   (*c*) Late hemorrhagic glaucoma
3. Irritation of ciliary processes in cases of posterior dislocation of the lens
4. Lack of communication between the anterior and the posterior chamber
   (*a*) Seclusion of the pupil
   (*b*) Total posterior synechia
5. Obstruction of venous drainage in experimental and in clinical glaucoma following obstruction of the vortex vein and in pulsating exophthalmos
6. General vascular hyperemia—including the hyperemia and changes following concussion (traumatic glaucoma) and the histamine-like reaction of epidemic dropsy
7. Congenital anomalies
   (*a*) Hydrophthalmos
   (*b*) Juvenile glaucoma
   (*c*) Glaucoma associated with nevus flammeus or with neurofibromatosis

used in the diagnosis of glaucoma.[34] In contrast to the effect of pupillary dilatation in patients with acute glaucoma, pupillary dilatation in patients with simple glaucoma has little or no effect. In these patients the tension rises slightly because of the decreased capillary wall surface available for osmotic absorption of the portion of the aqueous absorbed by the iris.

3. Congestion of the Ciliary Body: Any increase in the volume of the vascular bed of the ciliary body will obviously result in a slight

decrease in the depth of the chamber angle. Such congestion may be associated with neurovascular factors, with excitement, with weeping or other emotional experience, with disease of the respiratory tract such as influenza and rhinitis and with surgical procedures about the head. Friedenwald [42] has presented evidence from the results of injection of histamine into the vitreous of dogs that acute glaucoma is due to a vascular reaction in the ciliary body characterized by dilatation and increased permeability of capillary walls. That this is only one of several precipitating factors has been shown in a previous study [13] of lack of congestion early in the course of acute glaucoma in 49 clinical cases.

The classification of glaucoma which I have suggested is based on the clinical evidence presented heretofore that one is dealing with two distinct disease groups when one speaks of so-called primary glaucoma, namely acute glaucoma and simple glaucoma.

The largest subgroup of glaucoma, etiologically speaking, is due to interference with the reabsorption of aqueous into Schlemm's canal. The subdivision into failure of osmotic forces and mechanical closure of the angle by iris is entirely arbitrary and is based on the gross appearance of the chamber angle. In the group of conditions listed under failure of osmotic forces, the chamber angle is open. In the second group, the angle is grossly blocked by the base of the iris. With a classification such as this, the vascular reaction of the eye being considered as a phase through which any glaucomatous eye may, but need not, pass, all the clinical forms of glaucoma may be properly classified and understood and consequently better treated.

Barnes General Hospital (United States Army).

42. Friedenwald, J. S., and Pierce, H. F.: The Pathogenesis of Acute Glaucoma: II. Experimental Study, Arch. Ophth. **3**:574 (May) 1930.

News and Notes

EDITED BY DR. W. L. BENEDICT

GENERAL NEWS

Postgraduate Lectures in Ophthalmology.—The following lectures to be given at the University of Glasgow in the department of ophthalmology this fall will be open to any medical members of the allied forces who may care to attend: September 9, Professor Riddell, "Certain Aspects of Retinal Function"; September 16, Dr. Bacsich, "Comparative Anatomy of the Retina"; September 23, Professor Lowenstein, "Lipoid Degeneration of the Retina"; September 30, Professor Ballantyne, "Venous System of the Retina"; October 1, Dr. Eugene Wolff, "Normal Histology of the Retina," and October 2, Dr. Eugene Wolff, "Pathologic Histology of the Retina." Visitors will be welcome in the department of ophthalmology at any time.

PERSONAL NEWS

Dr. Frank H. Rodin Awarded Grant.—Dr. Frank H. Rodin, of San Francisco, has received a grant of $20,000 from the Columbia Foundation to conduct research in ophthalmology. The work will be carried out at the Mount Zion Hospital research laboratories, in San Francisco, under the direction of Dr. Rodin and of Dr. Charles Weiss.

The study will include the bacteriology and the immunology of the eye. It is planned first to study the flora of the normal eye and of common diseases of the eye. Later, special problems will be undertaken.

Dr. Troncoso Honored.—Dr. Manuel Uribe Troncoso was awarded the Howe Research Medal of the Section on Ophthalmology of the American Medical Association at the 1942 meeting, held in June in Atlantic City, N. J.

CORRECTION

In the article by Dr. W. D. Horner, "Dinitrophenol and its Relation to Formation of Cataract," in the June issue (ARCH. OPHTH. **27:** 1097, 1942), the last word in the first paragraph on page 1121 should be "unsuccessful" instead of "successful."

Obituaries

HERBERT HERBERT, F.R.C.S., L.R.C.P.

1865-1942

Lieut. Col. Herbert Herbert was born in Tranmere, Cheshire, England, and was educated at the University of Leeds. He qualified in 1886 and became a fellow of the Royal College of Surgeons in 1891. He entered the Indian Medical Service as surgeon in 1887 and attained the rank of lieutenant colonel in 1907 when he retired. In 1897 he was appointed ophthalmic surgeon of the Sir C. J. Ophthalmic Hospital, Bombay, and professor of ophthalmic surgery in the Grant Medical College in Bombay. After his return to England he practiced in Nottingham and was connected with the Nottingham and Midland Eye Infirmary. After the war, in which he served on a hospital ship and in Salonika, he moved to Worthing and became ophthalmic surgeon to the Worthing Hospital.

The large material to which he had access in Bombay enabled him to become an excellent clinician, and he worked at the same time in the pathologic field with true scientific spirit. His first contribution was one of the earliest communications on superficial punctate keratitis, which he had observed in an epidemic in Bombay. He was the first to describe pits in the cornea in trachoma and the presence of eosinophile cells in vernal catarrh. Together with a number of other investigators he worked on the operative problem of chronic glaucoma when simple iridectomy was found inadequate. He devised a number of operations, and the so-called trap door sclerectomy was his final effort. This consisted in cutting a small rectangular trap door in the sclera just outside of the limbus with a hinge toward the cornea.

In addition to a book on "The Operative Treatment of Glaucoma," in 1923, he wrote "The Practical Details of Cataract Extraction," 1903, and "Cataract Extraction," 1908. Herbert was a regular attendant at the Oxford congress and at the meetings of the Ophthalmological Society of the United Kingdom, of which he was at one time vice president.

ARNOLD KNAPP.

CHARLES HOWARD USHER, M.B., B.Ch.

1865-1942

Dr. Usher was born of a well known Edinburgh family in 1865. He received his general education at Cambridge and his medical education at Edinburgh and at St. Thomas' in London. He became ophthalmic surgeon at St. Thomas' under E. Nettleship, who induced him to take up ophthalmology as his life work. After serving as Nettleship's clinical assistant at Moorfields, Usher returned to Scotland and settled in Aberdeen as ophthalmic surgeon, and he was active on the staff of the Royal Infirmary for many years.

His medical writings, which show the influence and are an elaboration of Nettleship's own line of research, were "On the Courses of the Optic Nerves" and "On an Analysis of the Consumption of Tobacco and Alcohol in Cases of Tobacco Amblyopia," and he was a co-author of "A Monograph on Albinism in Man."

He was a prominent member of the Ophthalmological Society of the United Kingdom and was its president from 1927 to 1929, when he was awarded the Nettleship prize for investigations into hereditary diseases of the eye. He also received the honorary fellowship of the Royal Society of Medicine. He delivered the Bowman lecture in 1935, reporting on "Hereditary Eye Affections" and including an unusual pedigree of retinitis pigmentosa occurring in a family which he had been able to follow for forty years.

He was a man of strong personality, quiet and reserved in demeanor and of high scientific attainment.

Arnold Knapp.

Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

Aqueous Humor

THE PROTEIN CONTENT OF THE RE-FORMED AQUEOUS HUMOR IN MAN. P. C. KRONFELD, C. K. LIN and T. H. LUO, Am. J. Ophth. **24:** 264 (March) 1941.

Kronfeld, Lin and Luo give the following summary of their experiments:

"The protein content of the re-formed acqueous (P_2) was determined on eyes that could be considered as normal controls, on eyes of patients with retrobulbar neuritis, and eyes of patients with optic atrophy. P_2 was found to vary within $\pm$ 15 per cent of the average of the same eye, within somewhat wider limits in different patients. The lowest P_2 found was 31 mg. per cent; the highest 1000 mg. per cent. The portion of the chamber contents which was aspirated and the anesthetic were found to have a marked influence on P_2, whereas the time interval between the first and second ACP—within limits of from 10 to 60 minutes after the first ACP—had no noticeable effect. To account for the marked variations of P_2 in different individuals, a strong individual factor had to be assumed, the nature of which has not as yet been determined."

W. S. REESE.

Conjunctiva

SULPHONAMIDES FOR OPHTHALMIA NEONATORUM. Correspondence, Brit. M. J. **2:** 749 (Nov. 22); 887 (Dec. 20) 1941.

William J. Clancy, obstetric officer in the City General Hospital, Sheffield, England, writes that the introduction of sulfapyridine (2-[paraaminobenzenesulfonamido]-pyridine) and sulfathiazole [paraaminobenzenesulfonamido]-thiazole has greatly simplified the treatment of ophthalmia neonatorum. The dose of either drug is 0.125 Gm. every three hours for the first twenty-four hours, every four hours for the next twenty-four hours and every six hours for four days. The drugs are given crushed in sweetened water and are well tolerated, but their use should be stopped if they cause vomiting or a diffuse rash appears. The response is always prompt; in twenty-four hours the edema of the lids will be much less, and in forty-eight hours the discharge will have almost ceased and the eyes will be open. Clancy has treated many patients in the past three years with most satisfactory results, and the infants were never kept in the hospital for more than seven days.

The advent of these drugs has rendered local treatment of the infected eyes unnecessary, except that there should be an instillation of medicinal paraffin to prevent the lids from sticking together. The services of a special nurse and frequent irrigation are no longer necessary.

Dr. L. B. Somerville-Large, of Dublin, thinks the fact cannot be too strongly emphasized that since the introduction of these drugs the treatment of ophthalmia neonatorum has been revolutionized. It is no longer important to investigate the bacteriologic agent of the condition, and local treatment is relatively unnecessary. The author's routine is to give 0.125 Gm. of sulfapyridine with each four hour feeding for forty-eight hours and then discontinue the treatment. By this time the edema will have disappeared, the discharge will have almost ceased and the eyes will be on a fair way to full recovery. Local treatment simply consists in the frequent swabbing away of the discharge and the instillation of an oily drop. Somerville-Large has never seen sulfapyridine used in this way cause any complications, nor has he known the condition to resist treatment, and it is his teaching in the Rotunda Hospital that failure to administer a sulfanilamide derivative immediately ophthalmia neonatorum is recognized amounts to criminal negligence.

ARNOLD KNAPP.

SULFAPYRIDINE IN OPHTHALMIA NEONATORUM. A. SORSBY, E. L. HOFFA and E. W. SMELLIE, Brit. M. J. **1**: 323 (March 7) 1942.

Infants with ophthalmia neonatorum at the White Oak Hospital, London, are subjected to the following routine management: A swab of the pus is taken, both for a smear preparation and for culture. The eyes are irrigated with a bland solution, such as 0.5 per cent saline solution; 1 drop of atropine sulfate and drops of medicinal paraffin are instilled, and one half of a tablet (0.25 Gm.) of sulfapyridine (2-[para-aminobenzenesulfonamido]-pyridine) crushed into powder is given by mouth in a teaspoonful of water or milk. The administration of sulfapyridine is continued in doses of 0.125 Gm. every four hours, day and night, until twenty-four hours after a clinical cure is obtained. This usually means treatment for three to five days, with a total dose of about 2.5 to 4 Gm. Local treatment consists of three hourly irrigations with saline solution during the first day in cases in which there is a profuse discharge. As a rule no further irrigations are necessary. After irrigation medicinal paraffin is instilled to prevent the sticking together of the lids. If the cornea should become hazy or ulcerated atropine sulfate is instilled three times a day.

Under this treatment the swelling of the lids subsides within twelve hours after admission, the purulent discharge disappears within twenty-four hours and a threatened purulent ophthalmia becomes a simple conjunctivitis. The eyes are either dry or nearly so within seventy-two hours.

An account is given of 273 patients with ophthalmia neonatorum treated with sulfapyridine and of a control group of 46 patients treated by the classic methods of local therapy. The results obtained justify the claims made for this remedy. Sulfapyridine has proved as effective in nongonococcic ophthalmia as in the gonococcic variety.

ARNOLD KNAPP.

Congenital Anomalies

COLOBOMA OF THE OPTIC NERVE IN THE HUMAN EMBRYO. B. F. PAYNE, Am. J. Ophth. **24:** 386 (April) 1941.

Payne gives the following summary:

"1. An overgrowth of the retinal elements in a 61-mm. human embryo resulted in the inclusion of a fold of the retina in the optic nerve on the temporal side.

"2. The pigment epithelium was not included in the fold.

"3. Glial and mesodermal tissue replaced normal nerve markings on the temporal side, with disorganization of the columns of nuclei.

"4. From the histologic picture it is assumed that central vision would have been lost because of an interference with the papillomacular bundle had the embryo developed to maturity." W. S. REESE.

Cornea and Sclera

EQUATORIAL SCLERAL STAPHYLOMA AND RETINAL DETACHMENT CURED BY EXCISION. D. VAIL, Am. J. Ophth. **24:** 403 (April) 1941.

Vail reports the case of a 57 year old woman with a scleral staphyloma which was discovered when a diathermy coagulation operation was about to be performed for an underlying retinal detachment. It was then decided to excise the staphyloma by a method similar to that used by Lindner for shortening the eyeball. Convalescence was uneventful, and two years later there was no sign of any detachment, corrected vision was 20/40 and the patient read Jaeger type 1 slowly, missing some of the longer words. W. S. REESE.

CONTACT GLASSES IN KERATOCONUS AND AMETROPIA. E. AMORETTI, Arch. de oftal. de Buenos Aires **15:** 510 (Oct.) 1940.

Amoretti has been using contact glasses for keratoconus for the last twenty years with great visual benefit to his patients. For the last five years he has used them in cases of ametropia, mostly instances of high myopia. No traumatic or other injurious effect was noted. The author explains his method and reports in detail 22 cases of high myopia in which contact glasses were employed. Intolerance resulted in only 3 cases. C. E. FINLAY.

General Diseases

ACCIDENTAL INVOLVEMENT OF THE EYES IN VACCINIA. A. O. PFINGST, Am. J. Ophth. **24:** 257 (March) 1941.

Pfingst reports a case of vaccinia in a dairyman aged 71 after an epidemic of cowpox among his cows. His left eye first and then his right eye burned and itched. The symptoms increased, and the lids of both eyes swelled and discharged water and then mucopus. Examination revealed chemosis of the bulbar conjunctiva and some hemorrhagic areas. Eversion of the left upper lid revealed a 3 mm. ulcer on the

conjunctival surface near the middle, close to the lid margin, from which blood oozed. The right cornea was slightly infiltrated at its upper margin, and the preauricular glands were enlarged and tender.

W. S. Reese.

Syphilis in Ophthalmology. E. W. Assinder, Brit. J. Ophth. **26:** 1 (Jan.) 1942.

This is the Middlemore Lecture for 1941. The subject of syphilis in ophthalmology is presented from the viewpoint of a nonophthalmologist, and the article does not lend itself well to abstracting.

The total number of persons given the Wassermann test was 6,839. Of these, 1,015 gave a positive or weakly positive reaction. The number of positive reactions in 1940 was less than one third of that in 1928.

There were 19 patients with gumma in the orbital area. Tumors of the orbit demand a blood examination as one of the first examinations in a differential diagnosis. There were 17 patients with scleritis and episcleritis. The process is gummatous.

Of the 553 patients with keratitis, the majority had the diffuse interstitial type. About 97 per cent had the congenital variety. Of 100 consecutive patients with keratitis of the congenital type, 85 gave a positive Wassermann reaction; 14 of the 15 who gave a negative reaction had had previous antisyphilitic treatment. Injuries of all kinds and pregnancy may be exciting causes of the keratitis. In 43 per cent the keratitis was limited to one eye. The average age at onset of the patients with the congenital type was 18 years. Of 100 patients, 65 had peculiarities of the teeth and physiognomy and 10 were deaf. The arsphenamine compounds and bismuth are the best drugs in the treatment of syphilis. Assinder is convinced that hot fomentations prolong the florid stage of keratitis and result in denser corneal scars.

There were 96 patients with iritis, including cyclitis. No child under 1 year of age had iritis. In 15 patients the iritis was associated with acute syphilis. There were 87 patients with choroidoretinitis; in the great majority it was of congenital origin. There were 74 patients with optic nerve atrophy, 19 with optic neuritis and 119 with nerve palsies, including Argyll-Robertson pupils.

The process in locomoter ataxia is slow strangulation of the nerve fibers and the vessels in the nerves, combined with arteritis, causing perivascular scarring and thickening, with resulting atrophy of the nerve cells in the retina leading to atrophy of the fibers as shown at the disk, which leads to the question: "Is the atrophy of the disk really primary?"

W. Zentmayer.

Hygiene, Sociology, Education and History

War-Time Street Lighting and Aids to Movement in Street. Brit. J. Ophth. **25:** 125 (March) 1941.

This is a summary of the report on the fundamental requirements underlying war time street lighting prepared for the Joint Committee

of the Ministry of Home Security and the Illuminating Engineering Society.

The report will appear in full in the society's "transactions."

W. ZENTMAYER.

THE EDUCATION OF AN OPHTHALMIC SURGEON. A. LOWENSTEIN, Brit. J. Ophth. **26:** 45 (Feb.) 1942.

This communication does not lend itself well to abstracting. However, it makes most interesting reading and is replete with excellent suggestions to the young ophthalmologist.

The author recommends the following preparation for a graduate in medicine who wishes to specialize in ophthalmology. The financial side, unfortunately, cannot be neglected. The author says: "I should recommend a young man to go first into pathology for three months to learn especially histological and bacteriological methods; then for three months at least into physiology to get a glance into experimental methods, animal experiments as well as self observation; and, last but not least, to get into contact with theoretical experts, a contact which should never be interrupted during his clinical work. The next six months should be dedicated to general surgery to learn the principles of asepsis; how to stop bleeding without being shocked and without losing his head; how to use different instruments, especially in bone operations, and how to make good sutures. To observe a neurosurgeon at work forms a very useful part of the young man's education. So he will be better prepared for his future teamwork, urgently needed for successful clinical efficiency."

W. ZENTMAYER.

Injuries

MUSTARD GAS LESIONS OF THE EYES. I. MANN, Brit. M. J. **1:** 353 (March 14) 1942.

The author first draws attention to the cases of recurrent ulceration of the cornea which occurred among men who were subjected to relatively heavy doses of mustard gas ten to twenty years previously. The condition has been described as "delayed mustard gas keratitis."

The effects of mustard gas on the eyes depend on the size of the dose and on the structures involved; on these factors also depends the prognosis. There is no difference between the effect of the vapor and that of a splash of the liquid other than the degree.

The lesions can be well divided into three groups: 1. Those in which only the conjunctiva and the lids are involved. The symptoms are relatively mild and clear up after four to seven days. 2. Those in which, in addition to the lids and the conjunctiva, the surface layers of the cornea are involved. The important symptoms particularly lacrimation and photophobia, develop about six hours later. The cornea shows a superficial edema and epithelial bedewing. There is fine punctate staining with fluorescein. The patient tends to keep the eyes closed for four to five days, and then the condition gradually improves. 3. Those in which the whole thickness of the cornea is involved, together with the limbal blood supply. The injuries are severe, and the effects

may exist for a year or more. At the limbus on each side of the cornea there are whitish necrotic patches, and there is a band of dense edema across the cornea in the exposed part. The eyes remain closed five days, and then gradual improvement occurs. Or the eyes remain closed for a number of weeks, with profuse discharge and intense discomfort, and secondary edema makes its appearance accompanied by ingrowth into the cornea of vessels which assume characteristic and fantastic shapes. A faint nebula is left in the substantia propria. The severer reactions are characterized by relapses, and after a number of years the eyes are liable to a degenerative corneal ulceration (delayed mustard gas keratitis). Finally, the most severe reactions go on to perforation of the cornea. These are fortunately extremely rare.

The author concludes that the changes set up by the gas generally tend toward self limitation and spontaneous recovery, the results being better than the initial condition suggests. Treatment is symptomatic, and the patient should be reassured as to the ultimate outcome.

ARNOLD KNAPP.

Lacrimal Apparatus

"CROCODILE TEARS" TREATED BY INJECTION INTO THE SPHENOPALATINE GANGLION. B. H. GOTTESFELD and F. H. LEAVITT, Arch. Neurol. & Psychiat. **47:** 314 (Feb.) 1942.

A case of lacrimation during eating, coming on two years after a facial palsy, is presented.

Following the suggestion of Spiller, who attributed the phenomenon of crocodile tearing to regeneration of nerve fibers so misdirected as to fail to reach the muscles formerly supplied, the authors tried cocainization for interrupting the regenerating fibers.

The test of cocainization of the posterior naris as a clue to effective treatment gave relief in the case reported. When cocainization is effective, injection of absolute alcohol into the sphenopalatine ganglion by way of the posterior palatine foramen is recommended, with reinjection of alcohol if there is a return of symptoms.

R. IRVINE.

Lens

SPHEROPHAKIA WITH GLAUCOMA AND BRACHYDACTYLY. S. J. MEYER and T. HOLSTEIN, Am. J. Ophth. **24:** 247 (March) 1941.

Meyer and Holstein report 4 cases of spherophakia. They quote Marchesani, who stated the belief that spherophakia is part of a syndrome characterized by short stature, short hands and fingers, a broad thorax, a strong musculature and a brachycephalic head. They also speculate on the genesis of this condition and the reason why the peripheral field and the corneal epithelium are fairly well preserved even after high tension has been present over a period of years.

W. S. REESE.

DROUGHTS AS FACTORS IN THE DEVELOPMENT OF SENILE CATARACT. P. W. SALIT, Am. J. Ophth. **24:** 310 (March) 1941.

Salit found sudden marked increases in the incidence of cataract during the years immediately following or during state-wide droughts as reported by the United States Weather Bureau. He concludes that some of the agencies responsible for senile cataract are prolonged exposure to intense sunlight, dust and wind and extreme changes in the outdoor temperature and humidity. W. S. REESE.

Methods of Examination

EXAMINATION OF LIGHT PERCEPTION BY SIMPLE MEANS, WITHOUT AN ADAPTOMETER: REPORT OF CASES. W. COMBERG and H. RAUHUT, Klin. Monatsbl. f. Augenh. **104:** 502 (May) 1940.

Light perception is as important as the visual acuity and the field of vision in an examination of the functioning of an eye. Examination with the adaptometer is too cumbersome in daily practice. Comberg demonstrated a simplified and quick method at the Heidelberg meeting in 1938. It could be used in monocular disease only, as the light perception of the healthy eye had to be used for comparison. The improved method discussed in this paper is practiced with a small lamp fitted with an Aubert diaphragm. It is the perpalpebral method employed with closed eyes after one-half hour's dark adaptation. The threshold of light perception is found by pushing the patient in a wheel chair toward the lamp. The usefulness of the lamp is illustrated by brief histories of 14 patients with various diseases of the retina and choroid, cataract, glaucoma and traumatic lesions.

The authors point to the advantage of this apparatus over others, e. g. the Birch-Hirschfeld adaptometer, and declare that it may be used in the presence of opacities of the media. K. L. STOLL.

ANGIOSCOTOMETRY AND ITS DIAGNOSTIC VALUE. N. A. VISHNEVSKIY, Vestnik oftal. **17:** 571, 1940.

This study of angioscotometry had a twofold purpose. The author wished to discover (1) the changes in the angioscotomas in diagnosed diseases of the eye and (2) the value of angioscotometry for early diagnosis. The ordinary and the Dashevsky method of using contrast objects were employed. The study was made on 64 normal eyes, 71 eyes with optic and retrobulbar neuritis, 49 eyes with atrophy of the optic nerve, 18 eyes with thrombosis of the central vein, 34 eyes with maculitis, 196 eyes with glaucoma and 69 eyes with other diseases. A number of perimetric charts and curves illustrate the article.

Vishnevskiy came to the following conclusions: 1. Angioscotometry is an additional method not only for diagnosis but for prognosis in some diseases of the eye and is an aid in estimating the effectiveness of certain methods of treatment. 2. Angioscotomas change in size not only in certain pathologic conditions but in certain physiologic conditions. 3. Angioscotomas change in the following ocular diseases: neuritis, retrobulbar neuritis and choroidal disease. The greatest changes

in size were observed in chronic glaucoma and in inflammation of the optic nerve. 4. A definite relation between the blindspot and the angioscotoma and between the size of the latter and the visual acuity and the intraocular tension could not be established. 5. In some cases the data for diagnosis depended not so much on the absolute size of each angioscotoma as on a comparison of the two. 6. The relation of the size of the angioscotoma and the sensitivity of the eye to light could not be established.

O. SITCHEVSKA.

Neurology

OBSERVATIONS ON REFLEX RESPONSES DURING PROLONGED PERIODS OF HUMAN REFRIGERATION. T. FAY and G. W. SMITH, Arch. Neurol. & Psychiat. **45:** 215 (Feb.) 1941.

Neurologic studies were made on 42 patients during a state of reduced generalized body temperature.

The corneal reflex remained fairly constant and was demonstrated in 4 patients with a rectal temperature as low as 78 F.

The pupils remained equal, regular and normal in size throughout the hypothermic period, but response to light stimuli became progressively more sluggish as the body temperature was lowered. The light reflex became abolished at 78 F.

R. IRVINE.

TUMORS OF THE BRAIN IN AGED PERSONS. F. P. MOERSCH, W. McK. CRAIG and J. W. KERNOHAN, Arch. Neurol. & Psychiat. **45:** 235 (Feb.) 1941.

From the authors' review of 100 cases of verified tumor of the brain occurring among patients 60 years of age or more, it appears that the incidence of tumor of the brain in the aged is more common than is usually appreciated. Glioblastoma multiforme, meningioma and acoustic neuroma, in the order named, made up 82 per cent of the tumors in this series of cases. The cerebrum was the most common site of development of tumor, tumors in this region constituting 69 per cent. In the posterior fossa the cerebellopontile angle was the usual site of the neoplasm, which usually was an acoustic neuroma. As a result of the penalties of advancing years, the symptoms and signs of tumor of the brain were exceedingly variable and at times resulted in difficult diagnostic problems. The presence of papilledema or defects in the fields of vision was an important diagnostic aid; however, their absence could not be accepted as proof of the absence of a tumor of the brain.

In 96 of the 100 patients the ocular fundi were examined. In 32 patients papilledema was present, and in 8 patients there was evidence of atrophy of the optic nerves. Of these 32 patients, the results of perimetric examination were normal for 19. Eighty-eight patients had perimetric examination, 32 of whom had defects in the field of vision; 14 of the 32 patients had no evidence of papilledema. These facts are interesting, and also important, because they demonstrate the value of papilledema as a diagnostic sign, and they also emphasize the great care that must be exercised in diagnosis when the patient is not affected by papilledema. It would appear on the basis of this study that papilledema

accompanies tumor of the brain less frequently in aged persons than in younger persons. The value of careful performance of perimetric tests cannot be minimized, for in the 32 instances mentioned previously the positive field defects were of localizing value and in 14 of these 32 cases there was no evidence of papilledema.

R. IRVINE.

INGESTION OF LARGE DOSES OF DILANTIN SODIUM. C. D. ARING and M. ROSENBAUM, Arch. Neurol. & Psychiat. **45:** 265 (Feb.) 1941.

"Merritt and Putnam have recorded the toxic manifestations that may be associated with the therapeutic use of the anticonvulsant drug dilantin sodium (sodium salt of diphenylhydantoin). The untoward symptoms which might be attributed to the effect of the drug on the nervous system are blurring of vision, diplopia, nausea, dizziness, ataxia and tremor. . . .

"The case is recorded of a young man who on three occasions ingested 60, 90.5 and 105 grains (3.9, 5.883 and 6.825 Gm.), respectively, of dilantin sodium over a period of minutes, six hours and ten hours. The chief symptoms were exhilaration, light headedness, dizziness, nausea and vomiting, headache, staggering, diplopia, nystagmus, difficulty in converging the eyes, pupillary abnormalities, ataxia, tremor and changes in reflexes. Of all these signs, nystagmus persisted the longest, and was present for eight days on the last occasion. Significant laboratory findings were the acute elevation of the number of white cells in the blood and an elevation of the cerebrospinal fluid protein."

R. IRVINE.

METAMORPHOPSIA AND OTHER PSYCHOVISUAL DISTURBANCES IN A PATIENT WITH TUMOR OF THE BRAIN. M. B. BENDER and M. G. KANZER, Arch. Neurol. & Psychiat. **45:** 481 (March) 1941.

Psychovisual disturbances in a patient with tumor of the brain are described; the symptoms were lilliputian hallucinations, visual inattention, metamorphopsia, micropsia, macropsia and sensorimotor incoordination of the visual functions. Psychologic aspects of these visual disorders are discussed.

R. IRVINE.

STUDIES ON THE CORPUS CALLOSUM: II. THE HIGHER VISUAL FUNCTIONS IN EACH HOMONYMOUS FIELD FOLLOWING COMPLETE SECTION OF THE CORPUS CALLOSUM. A. J. AKELAITIS, Arch. Neurol. & Psychiat. **45:** 788 (May) 1941.

The author's summary and conclusions are as follows:

"In 6 epileptic patients in whom the corpus callosum was completely sectioned the higher visual functions in each homonymous field were studied. No disturbance of absolute or relative orientation, absolute or relative discrimination of size or recognition of color, objects or letters was found in either homonymous field of vision.

"These findings suggest (1) that the mechanisms for these visual functions reside within each hemisphere or (2) that subcortical commissural systems provide a sufficient interplay between the two hemispheres to

allow control of the 'subordinate' hemisphere by the dominant hemisphere. In view of present knowledge this explanation is improbable.

"Consequently, this investigation furnishes no support for the theory that a unilateral cerebral dominance exists in the elaboration of visual perceptions."

R. IRVINE.

Orbit, Eyeball and Accessory Sinuses

ON THE PATHOLOGY OF CAROTID-CAVERNOUS ANEURYSMS (PULSATING EXOPHTHALMOS). W. E. DANDY and R. H. FOLLIS JR., Am. J. Ophth. **24:** 365 (April) 1941.

This interesting article does not lend itself to abstracting. Two cases of bilateral carotid-cavernous aneurysm, presumably post-traumatic, are reported in detail, including surgical treatment and autopsy observations. A summary of the vascular changes is given and the unusual clinical features discussed.

W. S. REESE.

The Pupil

THE TONIC PUPIL SYNDROME. P. W. LEATHART, Brit. J. Ophth. **26:** 60 (Feb.) 1942.

Leathart discusses the physical signs of the syndrome and the anatomy of the ocular reflexes concerned and postulates by deduction the location of a lesion capable of producing the ocular symptoms and also the loss of knee and ankle jerks, which are a part of the syndrome, the physical signs which clearly differentiate the tonic pupil syndrome from tabes.

The author believes that the physical signs of the syndrome can be produced by destruction of the ciliary ganglion. Since it would appear impossible to produce them by a lesion in any other situation, one may postulate a lesion due to defective conduction between preganglionic and postganglionic fibers in this structure with some confidence. One may postulate also a lesion, producing the loss of knee and ankle jerks, in the sacral and lumbar segments of the cord itself, in the intercalated fibers connecting the posterior root fibers with the anterior horn cells, a lesion due to some error of conduction in the synapses there, analogous to that postulated in the ciliary ganglion for the loss of the light reflex.

W. ZENTMAYER.

Retina and Optic Nerve

RETINITIS PUNCTATA ALBESCENS. F. PONCE DE LEON and R. A. MAFFRAND, Arch. de oftal. de Buenos Aires **15:** 582 (Nov.) 1940.

Three cases are reported in a single family; there were hemeralopia, visual field contraction and the usual objective lesions. The literature is reviewed, and opinions as to the relations of the disease to retinitis pigmentosa and allied conditions, with the differential diagnosis, are discussed.

C. E. FINLAY.

PHYSIOLOGIC SECRETORY FUNCTION OF THE RETINAL PIGMENT EPITHELIUM. Y. KOYANAGI, Arch. f. Ophth. **142:** 304, 1940.

Koyanagi's theory that the retinal pigment epithelium by a process of secretion supplies the outer retinal layers with nutrient substances has been challenged by Kyrieleis (*Arch. f. Ophth.* **104:** 193, 1939) on the grounds that such secretory action has never been proved and that the part of the pigment epithelium is more likely to be that of passive penetration by fluid derived from the blood in the choriocapillaris by mere filtration. Since it is becoming more and more generally agreed that the ciliary epithelium is capable of secreting fluid, why should not the pigment epithelium of the retina be able to do the same? argues Koyanagi.' His concept of secretory function includes the elimination of unwanted metabolites from the retina and vitreous. As evidence for this concept he reports experiments in which after emptying of the anterior chamber an aqueous solution of toluidine blue was injected into the vitreous of albinotic rabbits. Histologic examination three to seven days later revealed selective staining of the pigment epithelium, while the ganglion cells and the visual epithelium of the retina remained unstained. In the choroid a few histiocytes were harboring granules of the blue stain. After repeated intravenous injection of the same dye the histiocytes of the choroid were heavily laden with blue granules, while the pigment epithelium remained unstained. Toluidine blue is insoluble in lipoid solvents and therefore does not enter living cells by purely physical force. Koyanagi interprets these experiments to indicate that the pigment epithelium is not a nonselective physical filter membrane, as Kyrieleis contends, but possesses selective permeability to a high degree.

P. C. KRONFELD.

Tumors

ORBITAL TUMORS AND THEIR SURGICAL TREATMENT. A. B. REESE, Am. J. Ophth. **24:**386 (April) 1941.

This is the first installment of a paper reviewing the findings in 174 consecutive cases of unilateral exophthalmos caused by tumors and tumor-like lesions. It includes only cases in which the diagnosis was verified by biopsy or other surgical measures. The various lesions are grouped and a number discussed from the standpoint of distinguishing characteristics, incidence, treatment and prognosis.

W. S. REESE.

NEUROFIBROMATOSIS OF THE IRIS. I. M. MAKLIN, Vestnik oftal. **16:** 216, 1940.

A patient gave the history of a growth on the lid for two years. A few years previously two tumors were removed from the shoulder and arm. The examination showed a free, soft, elastic tumor the size of a cherry on the left upper lid. A number of small round yellow nodules were seen on each iris with the slit lamp. The iris trabeculae were dilated. The eyes were normal otherwise. There were also a number of small, painless, pigmented tumors on the surface of the body along the peripheral nerves, so that Maklin feels justified in diagnosing the yellow nodules as neurofibromas of the irises.

O. SITCHEVSKA.

Vision

EXTRAFOVEAL VISUAL ACUITY AS MEASURED WITH SNELLEN TEST-LETTERS. E. LUDVIGH, Am. J. Ophth. **24:** 303 (March) 1941.

Ludvigh describes his method of testing extrafoveal acuity. He found that the letters used varied in legibility and that small central scotomas, even if complete, cannot cause the reduced vision ordinarily attributed to them. In many cases examined by the usual method of campimetry it can be shown that the apparent scotoma is really attributable to the reduced acuity rather than that the reduced acuity is caused by the scotoma.

W. S. REESE.

SHAMMING NIGHT-BLINDNESS. N. BISHOP HARMAN, Brit. M. J. **2:** 737 (Nov. 22) 1941.

Based on experience gained in World War I and in examining patients claiming workmen's compensation for ocular injuries, the following test for malingering was utilized:

"Two Snellen's test types are fixed one on each surface of the same board. On one side the regular range from 6/60 to 6/6 is fitted. On the other side the types range from 6/36 to 6/5, but the arrangement of these slightly smaller types matches in pattern and in general appearance the normal set of types. The patient is shown No. 1 test type; he reads three lines: V = 6/24. Now No. 2 test type is exposed; if he again reads three lines his vision is really 6/18, and he is convicted of inconsistency and suspected of shamming deficiency. The test is easy to apply and has proved to be useful."

Checking suspected shamming of bad night vision is a much more difficult problem. If there are good daylight vision, no discernible sign of defect disclosed by objective examination of the eyes and no general defect of health or nutrition, the author varies his disk spotting test as a check by varying the light and altering the size of the disks. The test may be made more difficult or more easy in three ways. If the disability is genuine, when the light is less the vision will be worse and when the light is brighter the subject will see much better and at a greater distance. He will also see better when he is shown larger disks. In making the variations it is desirable to have an assistant. Between each test the eyes of the subject should be covered so that there will be no actual observation of the changing of the conditions of the test.

ARNOLD KNAPP.

Therapeutics

LOCAL USE OF SULFANILAMIDE COMPOUNDS IN THE EYE. J. S. GUYTON, Am. J. Ophth. **24:** 292 (March) 1941.

Guyton gives the following summary of his experiments:

"1. Sulfanilamide compounds which are effective in vitro are of theoretical value when used locally for infections of the conjunctiva and cornea.

"2. Sulfanilamide in ointment form is at present the most suitable preparation for local use.

"3. In 18 cases of catarrhal conjunctivitis due to the ordinary infecting organisms, 5 per cent sulfanilamide ointment did not appear more efficacious than did an ointment base without the sulfanilamide.

"4. Two out of five cases of trachoma were improved but not cured by prolonged use of 5 per cent sulfanilamide ointment.

"5. Encouraging results have been obtained with the use of 5 per cent sulfanilamide ointment in the treatment of infected corneal ulcers."

W. S. REESE.

ADVANCES IN THE USE OF SULFANILAMIDE COMPOUNDS IN OPHTHALMOLOGY. J. S. GUYTON and A. C. WOODS, Am. J. Ophth. **24:** 428 (April) 1941.

Guyton and Woods give the following summary of their studies:

"1. A simple table of dosage for sulfanilamide, sulfapyridine [2-(paraaminobenzenesulfonamido)-pyridine], and sulfathiazole [2-(paraaminobenzenesulfonamido)-thiazole] is given.

"2. The toxic reactions of sulfanilamide, sulfapyridine, and sulfathiazole are enumerated.

"3. The drugs of choice at present in the treatment of various ocular infections are: (a) For gonococcal conjunctivitis, sulfathiazole is the drug of choice, and should be continued for about three days after the first smear. (b) For trachoma, sulfanilamide is the only drug that has been used extensively. A blood concentration of 6 to 11 mg. per cent, maintained for two to three weeks, is usually quite effective. (c) For beta-hemolytic streptococcus infections, sulfanilamide remains the drug of choice, although sulfapyridine and sulfathiazole are equally effective. (d) For staphylococcus infections, sulfathiazole is the most effective drug at present available, but even this drug is not very efficacious. (e) For pneumococcus infections, sulfapyridine and sulfathiazole are about equally effective. (f) For Koch-Weeks (H. influenzae) infections, sulfapyridine is more effective than sulfanilamide. (g) For meningococcus infections, sulfanilamide is quite effective, although sulfapyridine is probably a little better. (h) For infections due to B. coli and most related gram-negative bacilli, sulfathiazole is more effective than either sulfanilamide or sulfapyridine, but at best the therapeutic response is not too good. (i) For infections of unknown etiology, sulfathiazole is at present the drug of choice because it has the widest range of effectiveness. Prophylactic administration of sulfathiazole is recommended in cases of intraocular injury."

W. S. REESE.

Society Transactions

EDITED BY DR. W. L. BENEDICT

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

KAUFMAN SCHLIVEK, M.D., *Chairman*

BRITTAIN PAYNE, M.D., *Secretary*

Dec. 15, 1941

Surgical Construction of a Lacrimal Passage. DR. LOREN GUY.

This article will be published in full, with discussion, in a later issue of the ARCHIVES.

Interstitial Keratitis and Acute Dacryoadenitis. DR. CHARLES GREGORY BARER.

Syphilitic involvement of the lacrimal gland is rare. A few case reports of gummatous involvement in acquired syphilis appear in the literature. Only one report has appeared of acute inflammation of the gland with interstitial keratitis due to congenital syphilis.

The case which is reported is that of a Negro girl 14 years of age who in August 1940 began to have pain, photophobia, lacrimation and decrease in vision in the left eye. A Wassermann test of the blood was positive. Examination of the eyes showed a small area of infiltration in the right cornea, marked infiltration in the left cornea, edema of the left upper lid, a palpable, tender, swollen lacrimal gland and exophthalmos of the left eye which measured 3 mm. Twelve days later, after instillations of a 1 per cent solution of atropine sulfate into the conjunctival sac and the application of hot compresses to the skin over the left lacrimal gland, the acute symptoms subsided.

Two weeks later acute pain, swelling and tenderness of the right lacrimal gland developed in association with photophobia, lacrimation and pronounced infiltration in the right cornea. Anterior uveitis was present in both eyes. Instillations of atropine sulfate and application of hot compresses produced some relief of symptoms. Old arsphenamine was used after other preparations were found inadequate.

Since then, exacerbations have been intermittent. Antisyphilitic therapy was instituted, but the process was not controlled until intensive treatment consisting of injections of old arsphenamine was well under way.

Since March 1941 the process has been controlled, the exophthalmos has receded, pain, tenderness and swelling of the lacrimal gland have subsided and the anterior uveitis has become quiescent. There is still marked interstitial keratitis, but it is inactive.

DISCUSSION

DR. HOWARD D. H. BROWN: My own experience is rather limited with regard to this rare condition. The pathologic change is minimal in this type of adenitis. The reports in the literature almost exclusively concern acquired syphilis, and this case of syphilitic involvement of the lacrimal gland in the presence of congenital syphils is apparently the second to be reported. Nine months have transpired since the last period of inflammation, and, as Dr. Barer pointed out, one is not quite safe in saying that the condition is cured, for there have been three recurrences. Nevertheless, it is evident that the condition is pretty well controlled.

DR. HENRY MINSKY: I should like to point out an observation that I have made in cases of acute dacryoadenitis, especially those in which the condition has been unilateral. When the gland is palpable, the diagnosis is obvious, but if edema of the upper lid is confined to the temporal region and no gland is palpable, there is a pathognomonic sign that will help to clinch the diagnosis. The outer third of the orbital margin ordinarily is sharp, and in cases of acute dacryoadenitis that sharp margin is obliterated by edema deep in the tarso-orbital fascia that converts the sharp edge into a rounded one If a finger is held at the junction of the outer and middle two thirds and is gently pressed into the edematous lid until it finds the orbital margin, the finger is stopped from riding on it by a rather firm band, which disappears later, when the dacryoadenitis subsides. This band is probably a consolidation by edema of the fibrous extension of the levator tendon where it comes into relation to the lacrimal gland.

Kaposi's Sarcoma with Conjunctival Involvement. DR. ALAN BARNERT.

Kaposi's sarcoma is a chronic disease characterized by the appearance and growth of multiple nodules, especially of the skin of the legs and the forearms, although cutaneous nodules may occur anywhere on the body, including the face. The nodules are pea sized, discrete, firm, red or blue and not tender. Individual lesions may involute, but new lesions develop. Pathologically the lesions show a pronounced new growth of capillaries, hemorrhage and proliferation of connective tissue. The hemorrhage and the liberation of blood pigment are the cause of the bluish color of the nodules. The histologic picture resembles that of angiosarcoma, and it is because of this fact rather than because of the clinical course that the disease received its name of angiosarcoma. Aside from the cutaneous nodules, similar lesions have been found on mucous membranes in practically all organs of the body. The gradual development of these lesions usually causes the death of the patient in two to eight years. A large proportion of the patients with the disease are white men over 40 years who have migrated either from the neighborhood of Poland or from northern Italy.

The patient whose case I wish to report was a white man aged 85. He was born in Cracow, Poland. His past history was irrelevant except for bilateral cataracts, which were successfully extracted. and

episodes of blepharoconjunctivitis, each of which responded to local treatment.

Nine years ago he began to have unraised, colorless, painless keratotic lesions of the face and legs. A biopsy specimen was taken from a lesion on the nose which became ulcerated, and the pathologic process observed was basal cell carcinoma. The relation of the other lesions to the present condition was problematic.

In June 1938 edema of the right foot and ankle developed. A cause for this was not found. Two months later numerous discrete, erythematous, pea-sized tumefactions were noted on the right leg and forearm; some were indurated and some soft. Thereafter the patient had continuous crops of these swellings, usually only one or two at a time.

In November 1940 a small, red, movable cystic mass covered with smooth epithelium was noted in the right lower part of the fornix conjunctivae. At first it could be seen only by careful examination, but it grew rapidly in size. One month later it measured 9 by 5 by 5 mm., and it continued to grow. It was removed during local anesthesia. Microscopic examination revealed it to be typical Kaposi's sarcoma. In order to confirm this diagnosis a biopsy specimen from one of the cutaneous nodes was taken, and it showed the same process. The conjunctival cul-de-sac remained free from nodules, but six months later a new tumor appeared on the bulbar conjunctiva near the limbus at 2 o'clock. This had no apparent connection with the original mass. It was removed, and the microscopic examination of the tissue proved it to be Kaposi's sarcoma. At present, there is a red mass near the right inner canthus which apparently is a recurrence of the second tumor.

DISCUSSION

DR. FREDERICK H. THEODORE: About 400 cases of Kaposi's sarcoma have been reported in the literature, but probably more cases have been recognized in the large metropolitan areas and not recorded. In typical cases nodules appear, but in the case described by Dr. Barnert there was the flat, or plaquelike, type of lesion, which is less typical. The diagnosis was not made clinically until a nodule was removed and examined microscopically, although the dermatologists suspected Kaposi's sarcoma. The mucous membranes are often involved, particularly those of the gastrointestinal and of the respiratory tract, and it seems rather odd that cases of Kaposi's sarcoma of the conjunctiva have not been reported more frequently.

In 1938 I saw a patient with this type of sarcoma at the Herman Knapp Memorial Eye Hospital, a man 65 years of age in whom the involvement was extremely severe. Two nodules were present on the palpebral conjunctiva as well as one on the bulbar conjunctiva near the caruncle of the eye. The cutaneous nodules were so typical that the clinical diagnosis was made on admission. Subsequently, it was learned that several laryngeal nodules had been removed because of hoarseness. Thus the diagnosis of Kaposi's sarcoma had been confirmed pathologically. I presented this case at the clinical conference of the Herman Knapp Memorial Eye Hospital, but unfortunately the patient disappeared from sight and so could not be presented before the Section of Ophthalmology.

Keratoconus and Atopic Dermatitis. DR. BERTRAM S. KRAMER (by invitation).

The rare combination of keratoconus and atopic dermatitis (neurodermatitis) is demonstrated by 2 women. The first was 30 years of age, and her symptoms had been present in the skin and in the eyes at the age of 16. A paracentesis was performed on one eye by Dr. Clyde McDannald, after which there was no improvement in the condition. Cataractous changes are present.

The second patient was 25 years of age, and her symptoms also began at the age of 16. She was unable to wear contact lenses, and vitamin therapy with calcium did not improve the condition.

DISCUSSION

DR. RUDOLF L. BAER: I have seen many patients with atopic dermatitis associated with cataracts, but I have not had occasion to observe any with atopic dermatitis associated with keratoconus. Atopic dermatitis is a new name given to what used to be called disseminated neurodermatitis. According to the modern concept, atopic dermatitis is not associated with disturbances in the central nervous system, and because of this the name neurodermatitis was dropped and the disease was reclassified among the diseases in which it physiologically belongs, in the asthma and hay fever group. The cutaneous form of atopy, i. e. atopic dermatitis, is characterized by the same cardinal features as the other diseases belonging to this group. Patients suffering from atopic dermatitis give positive wheal reactions to intradermal or scratch tests; their blood serum usually contains reagins, i. e. passive sensitization antibodies; eosinophilia frequently is present, and in the majority of cases there is a family history of asthma, hay fever or atopic dermatitis. The term "atopic dermatitis" is meant to include infantile eczema, which is the first stage of atopic dermatitis. It is interesting to note that keratoconus was found in the 2 cases reported, since the condition in both was unusually severe. Patients suffering from atopic dermatitis usually outgrow the disease during the late teens or early twenties, and it is unusual for the disease to persist beyond the age of 25 or 30. There seems little question that atopic diseases are based on a hereditary tendency, and the question of cause arises in the cases reported—whether the appearance of keratoconus also was based on a hereditary tendency. I am not aware of any cases of keratoconus having been reported in which asthma and hay fever were associated, but it is probable, of course, that when other cases of keratoconus were observed, atopic diseases were not particularly investigated.

DR. VICTOR R. SYRACUSE: Knowledge concerning the pathogenesis of keratoconus and the genesis of atopy, known as neurodermatitis or rather atopic dermatitis, is scanty and suggestive at best. However, when the two conditions are found together, the ophthalmologist is reminded of the occurrence of atopic cataracts associated with neurodermatitis. Clinically, it is well known that the first phase or rather the precursor of dermatosis in an adult is infantile eczema in some cases. In other cases, three distinct phases are to be noted, namely dermatosis in infancy, dermatosis in childhood and irreversible dermatosis in maturity. These

different phases may be separated by year-long intervals of complete remission or freedom from atopic manifestations, or they may continue uninterruptedly and each be merged by imperceptible transition with the succeeding phase. A patient of mine, a man over 30 in whom atopic cataracts were successfully extracted with excellent visual results, also suffers from hay fever and asthma. Thus he has suffered three other atopic conditions.

Apropos pathogenesis, may I offer the following thought-provoking question? In adults may the cornea (in keratoconus) and the lens (in atopic cataract) be considered as two more shock organs in atopic, chronic dermatitis?

Highly suggestive are the reactions which appear principally in ectodermal, epithelial and avascular structures such as the lens, the cornea and the epidermis. This can be stated in another way. The patient may be susceptible to atopic cataract or keratoconus or dermatitis because of his atopic state. That his susceptibility is an inherited predisposition to react to immunologically related atopens is the best supposition one can make.

DR. MORRIS JAFFE: Since it has been pointed out that both patients were sensitive to a great number of foods, is it possible that abstinence from essential foods or possibly faulty elimination may have been contributing causes to the keratoconus?

DR. CLYDE E. MCDANNALD: I do not have a record of the case in which paracentesis was performed and have not sufficient recollection of this case to add anything to what has been said, but I should like to mention that I have observed 2 cases of so-called "neurodermatitis." One was that of a young man in whom bilateral cataracts developed and on whom I operated and obtained satisfactory results. The other was that of a young woman in whom keratoconus, secondary glaucoma and cataracts developed. I removed one cataract, but the patient would not submit to an operation for removal of the other.

DR. KAUFMAN SCHLIVEK: Did the patient suffering from atopic dermatitis associated with cataract receive radiotherapy to the face?

DR. CLYDE E. MCDANNALD: I do not know that she did. She did have the type of allergy that Dr. Kramer has described.

DR. KAUFMAN SCHLIVEK: Dr. Hartmann has had considerable experience with radiotherapy; has he had any cases like these?

DR. EDWARD HARTMANN, Paris, France: I have had experience with the use of roentgenograms in making diagnoses, but I have had little experience with radiotherapy. I have no recollection of cases like these.

DR. BERTRAM S. KRAMER: The blood pressure was normal in both cases. In one it was 112 systolic and 76 diastolic and in the other it was 118 systolic and 80 diastolic.

The menstrual history was similar in the 2 cases; menstruation began around the age of 16 or so. One patient was single, and the other was married. Both patients complained of a good deal of dysmenorrhea. The patient who was married told me that during pregnancy the dermatitis was aggravated; she said that her skin itched for nine months after she became pregnant. Other than this reaction, these cutaneous manifestation are not affected by menstruation.

As for vitamin deficiency, it is conceivable that both these patients may have been deficient in certain vitamins, but since they have been under observation in a good hospital they have been getting plenty of vitamins A and B and calcium. So, one can say that for the last two years lack of vitamins has not been responsible for their condition, and they have not benefited from the administration of vitamins.

Use of Padgett Dermatome in Ophthalmic Plastic Surgery. DR. BYRON C. SMITH.

This article will be published in full, with discussion, in a later issue of the ARCHIVES.

Experiences with Acetylcholine: Treatment of Ocular Pain. DR. EDWARD HARTMANN, Paris, France (by invitation).

This article will be published in full, with discussion, in a later issue of the ARCHIVES.

KAUFMAN SCHLIVEK, M.D., *Chairman*

BRITTAIN PAYNE, M.D., *Secretary*

Jan. 19, 1942

Heparin Treatment of Thrombosis of the Central Retinal Vein. DR. MARVIN CUTHBERT, Senior House Surgeon, New York Eye and Ear Infirmary (by invitation).

One of the most important therapeutic agents developed for the prevention and treatment of thrombosis and embolism is heparin. If added to freshly drawn blood or injected into an animal it prevents coagulation. The action of heparin may be explained more clearly by a brief review of the physiology of blood coagulation.

Normally the coagulation of blood occurs in two separate stages: First, calcium, thromboplastic substance and prothrombin unite to form thrombin; second, the reaction of the newly formed thrombin with fibrinogen produces fibrin, which makes up the fine meshwork of a blood clot, or thrombus. The thromboplastic substance is liberated from destroyed blood platelets, tissue extracts and all extravascular cells. Small amounts of it, therefore, must be present in the circulating blood all the time. Since thrombi are not constantly being formed, it must have an inhibitor, and this is thought to be heparin. Heparin is present in small amounts in the circulating blood. It is present in larger amounts in the lung, liver and vascular connective tissue. Heparin acts on the thromboplastic substance and splits off a phospholipid constituent, the two uniting to form a new substance, which not only causes the coagulation chain to break but is a powerful anticoagulant itself. One milligram of heparin will prevent the coagulation of 100 cc. or more of whole blood.

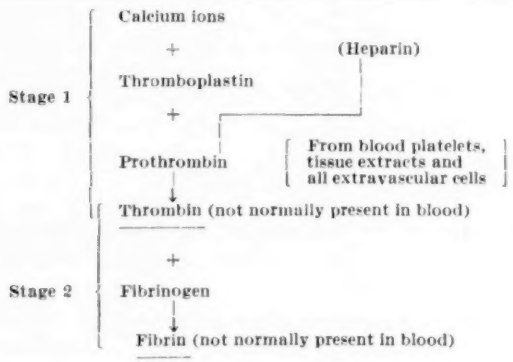
Heparin in the circulating blood is produced by the mast cells of Ehrlich, which are found mainly in connective tissue near capillaries

and in the walls of blood vessels. In the presence of peptone and of anaphylactic shock, the blood is almost incoagulable. Toxic effects of high fever and gastrointestinal symptoms greatly interfered in the early experimentation with this anticoagulant.

The effect of heparin when injected varies from one subject to another and in the same subject from time to time, and after surgical procedures heparin is less effective than before. Heparin is not eliminated by the lungs, kidneys or liver but is destroyed rapidly by the enzyme "heparinase." Single injections of heparin must be dangerously large if they are to be effective. The drug is best given by continuous intravenous injection.

Heparin can be used in blood transfusion either by mixing it with freshly drawn blood or by injecting 1 mg. per kilogram of body weight into the donor. When it is injected into the donor, the blood letting

Coagulation of Blood



is started within five minutes, and the donor's clotting time returns to normal in about two hours.

In cases of retinal vein thrombosis, treatment with heparin has given excellent results. Even in cases of complete thrombosis of the central vein of the retina, vision has been restored to 20/20. In thrombosis of a branch of this vein, return of vision to 20/20 is practically the rule when the treatment is started within twenty-four hours after the onset. Treatment with heparin should be continuous for five to fourteen days, but the vision may not return to normal before two or three months have passed.

DISCUSSION

DR. HOWARD LILIENTHAL: I wish to say something about an antithrombin which is much more powerful than heparin and which is more easily administered. I am speaking of hirudin. I hope that Dr. Cuthbert and his co-workers will experiment with this substance if they can and that they will use leeches, from which hirudin is excreted, instead. Leeches are much simpler to use than heparin. They can be applied almost anywhere on the surface of the body, and it is not necessary to

make experiments on the blood outside the body to see whether coagulation is deferred or prevented.

Heparin has certain dangerous aspects, and its application is not simple. I was greatly interested, however, to see that it has been used in the treatment of dogs affected by induced coronary thrombosis. I have been doing my best to influence physicians of my acquaintance to use leeches in the treatment of patients suffering from this disease, but they seem apathetic. I do not believe that coronary thrombosis should be regarded with indifference. As this treatment seems promising, I believe that it should be utilized.

I wish to say a few words concerning the use of leeches in the treatment of patients suffering from thrombosis of blood vessels other than those of the heart. About twenty-two years ago I performed an abdominal operation on a patient, and he made a good operative recovery but was in bed for months on account of a complicating venous thrombosis in the right leg. He returned twenty years afterward, at which time a two stage prostatectomy was performed. A few days after the first stage of the operation, venous thrombosis again developed in his right saphenous vein, and he had a temperature of 104 F. He was desperately ill. I had spoken with Alton Ochsner, of Tulane University, concerning "leeching," and he said he was convinced that it had great advantages. I administered it to my patient, and he recovered.

Hirudin is injected into the blood stream by the leeches, and it prevents clotting. The leech can ingest large quantities of blood. When it becomes engorged and drops off, the blood from the wound continues to flow freely until the hirudin in that region has disappeared, but if the hemorrhage is stopped immediately after seven or ten leeches have dropped off, the blood in the patient's body will not coagulate. I should think that hirudin would be even more effective in the treatment of patients suffering from thrombosis of the central vein of the retina than in the treatment of those suffering from thrombi occurring in the blood vessels of the heart. One should remember that there is the danger of pulmonary embolism if hirudin is used in the treatment of patients suffering from occlusion of large veins.

A friend of mine who is a physician was convalescing in a hospital of which he and I are members of the staff. He was suffering from thrombosis of the left saphenous vein, and he had a temperature of 102 F. I suggested to his physician that leeches be used. He did not know what purpose leeches could serve, and so I explained to him that their use might not be effective but that, on the other hand, no harm would be done in giving the treatment a trial. I described the case of my patient who had undergone prostatectomy. About eight months later I met my friend at a dinner and dance given by the hospital staff. He was dining and dancing without difficulty. He informed me that leeches had been used.

DR. JAMES W. SMITH: In the April 1941 issue of the ARCHIVES Dr. R. L. Rea reported on the use of heparin in the treatment of patients suffering from thrombosis of the central retinal vein. He did not give the substance continuously by the method which Dr. Cuthbert described. Dr. Rea observed in 1 case that after the fifth and the sixth injection flashes of violet light occurred in both eyes. I should like to ask Dr.

Cuthbert to explain this phenomenon and whether use of the drug should be discontinued when it appears. Is the use of heparin indicated in the case of hemorrhages into the vitreous?

DR. MARVIN CUTHBERT: I also read that article, and I cannot offer an explanation for the phenomenon.

In most cases of thrombosis of the central retinal vein, I believe that hemorrhages into the vitreous are present and are no contraindication to the use of heparin.

Molluscum Contagiosum of the Lid Margin with Pannus. DR. CLEMENT MCCULLOCH (by invitation).

The patient, an 11 year old white boy, gave a history of irritation of the left eye of three months' duration. Examination revealed hyperemia and a moderate follicular reaction of the conjunctiva, most pronounced in the lower fornix and at the upper border of the upper tarsus. There was diffuse punctate staining of the cornea. A pannus of 5 mm. extended down from the upper limbus, and a pannus of 2 mm. extended up from the lower limbus. A small yellowish nodule was present among the cilia near the outer margin of the upper lid, scrapings of which, stained with victoria blue, contained the elementary bodies of molluscum contagiosum. Inclusion bodies were not found in the conjunctival smears. Similar nodules were not found elsewhere on the body.

The nodule was removed. The inclusion bodies of molluscum contagiosum were present in the pathologic section. One week later the corneal and the conjunctival changes had subsided. Three weeks later a second nodule had developed at the site of the original one. The corneal and the conjunctival manifestations had returned. The second nodule was removed. Since then, recovery has been complete. The conjunctival follicles and hyperemia and the corneal staining and pannuses have disappeared. There has been no recurrence.

The clinical signs in this case resembled those of trachoma. The history of irritation of the left eye of three months' duration; the presence of conjunctival follicles, particularly on the upper tarsus; the staining of the cornea, and the pannus would ordinarily indicate trachoma. However, the nodule on the lid margin determined the diagnosis. This was verified by laboratory investigation of the contents of the nodule. In molluscum contagiosum, inclusion bodies are not found in conjunctival scrapings.

Corneal involvement caused by molluscum contagiosum is not rare. This subject has been summarized well by Offret and Duperrat (Les manifestations oculaires du "molluscum contagiosum," *Arch. d'opht.* **2:** 993 [Nov. 7] 1938).

DR. ALSON EMMONS BRALEY (by invitation): I had the opportunity to examine this patient, and unfortunately I saw him when the upper lid was everted. I made a diagnosis of trachoma, since follicles were present on the upper tarsus and pannus was advanced. Molluscum contagiosum of the lid is a relatively common disease, and it occurs in children as well as in adults, but most of the patients I have seen have been children. However, in a number of cases the disease has developed in adults. I can recall the case of a woman who had extremely troublesome unilateral con-

junctivitis that had been treated extensively with many types of chemotherapy without avail. A few small atypical lesions were removed from the eyelid, and sections were made of these which revealed the typical picture which Dr. McCulloch has described. The conjunctivitis undoubtedly was caused by molluscum contagiosum. The means by which conjunctivitis develops in such cases is difficult to explain. It is assumed, however, that the virus itself produces it. It has been interesting to note that unless the molluscum body is present some place in the vicinity of the lid border or in the lash line, conjunctivitis usually is not present. If the lesion is on the skin side of the lash line, and elementary bodies do not gain entrance into the conjunctival sac, the chances that conjunctivitis will develop are not great; however, if the lesion is on the lid border or in the cilia line, conjunctivitis frequently develops. I have not seen molluscum contagiosum of the lower lid which developed into pannus. However, this is the second or third case that I have encountered in which molluscum contagiosum of the upper lid was associated with pannus and in which a differential diagnosis of trachoma was made.

Tuberous Sclerosis. Dr. Murray Last.

This article will be published in full, with discussion, in a later issue of the Archives.

Clinical and Surgical Aspects of Pituitary Tumors. Dr. Leo M. Davidoff, Brooklyn.

Tumors of the pituitary gland manifest themselves by two primary sets of symptoms: (1) those caused by compression of the surrounding structures, chief among which are the optic chiasm and the optic nerves; (2) those caused by endocrine disturbances due to the abnormal secretion of the tumor itself or to interference with the normal secretions of the pituitary gland. The first set of symptoms, namely compression of the optic nerves and the chiasm, can also be produced by tumors in the neighborhood of these structures that do not arise from the pituitary gland itself. The differential diagnosis of primary tumor of the pituitary gland and tumor in the neighborhood of the chiasm often depends, therefore, on cognizance of various endocrinologic changes that accompany the visual symptoms. Discernment of a tumor in the region of the optic nerves and chiasm is not sufficient. Differentiation concerning the type of the tumor is necessary, since the form of therapy to be undertaken for each type must vary. Thus, for example, in the treatment of patients suffering from pituitary tumor the type of therapy differs according to the type of adenoma existing. Eosinophilic adenoma, with which acromegaly is associated and which is the simplest type to diagnose, responds to radiotherapy much more readily than the other types of pituitary adenoma. Radiotherapy, therefore, should always be given a trial in cases of pituitary tumor associated with acromegaly unless there is serious danger of immediate blindness. Chromophobe adenoma of the pituitary gland, on the other hand, frequently responds to radiation therapy. However, the percentage of cases of chromophobe adenoma in which the tumor responds to radiotherapy is smaller than

that for eosinophilic adenoma. In cases of chromophobe adenoma, too, irradiation should first be given a trial except when immediate surgical intervention is indicated.

Tumors such as suprasellar meningioma, which produce ocular symptoms similar to those occurring in association with adenoma of the pituitary gland, are completely unaffected by radiation therapy. It is important, therefore, to make a careful differential diagnosis so that immediate surgical intervention will not be deferred by subjecting the patient to radiation therapy first. Craniopharyngioma, on the other hand, is best treated by a combination of surgical intervention and radiation therapy. The surgical procedure should be performed first and radiation therapy be given afterward.

The clinical manifestations of chiasmal tumors are important criteria in determination of the final diagnosis and the type of therapy to be administered.

The operative procedure is usually the same for all types of lesions occurring in the region of the chiasm. The intranasal approach to the pituitary region is no longer advocated. Instead a transfrontal craniotomy is performed, through the opening of which usually the right frontal lobe is elevated and the tumor exposed from above. The fact should be emphasized that in adenoma of the pituitary gland, the lesion usually is interspersed with normal cells of the anterior pituitary lobe. It is, therefore, not only difficult but inadvisable to remove the entire lesion. The surgical procedure, therefore, is undertaken primarily to relieve or decompress the optic nerve and chiasm, as well as the pituitary gland and the hypothalamic region of the brain. With this fact in mind, it is easy to understand why radiation therapy should certainly be given after surgical intervention if it has not already been administered previous to the operation.

DISCUSSION

Dr. Cornelius G. Dyke (by invitation): The roentgenologic aspects of pituitary tumors were discussed.

Dr. Foster Kennedy (by invitation): Dr. Davidoff and Dr. Dyke have covered the different varieties of expanding lesions of the pituitary gland so well and so clearly that it is difficult to take any issue with them.

I am a little surprised at the figures which Dr. Dyke presented concerning the difference in benefit from radiation therapy to chromophil and to chromophobe adenoma. He stated that chromophil adenoma is more greatly benefited. I thought it was just the opposite, but I am sure that I do not know as much about the statistics in this regard as does Dr. Dyke.

The simple forms of pituitary adenoma are easy to diagnose. They can be distinguished readily on a roentgenogram. But in a number of diseases affecting the pituitary gland the situation is reversed. The patient's symptoms may be typical but the lesion obscure. For instance, it is difficult to differentiate migraine resulting from pituitary tumor, that produced by organic disease of the brain and that caused by localized edema occurring chiefly in the crevices of the brain at the base of the skull and in the reflections of the meninges. Migraine certainly can simulate symptoms which develop as a result of pituitary tumor. I have also observed cases in which a diagnosis was erroneously made

of pituitary tumor by competent neurologists on the basis that the patient suffered from attacks of bilateral homonymous hemianopia associated with persistent headache, and altered sex hormones were present in the urine. The symptoms fluctuate in cases of this type, and treatment should be delayed in order that the true cause of the distress can accurately be determined.

I agree with Dr. Davidoff concerning the advisability of administering radiotherapy first in the treatment of pituitary tumors. Sometimes after radiotherapy has been administered to an expanding lesion of the pituitary gland the vision becomes progressively reduced. The reduction may erroneously be attributed to congestion caused by the radiation. As Dr. Dyke has stated, if improvement in vision does not take place at once, it is likely that the lesion is cystic and is not affected by radiotherapy. Surgical intervention, therefore, is indicated. On the other hand, when the growth of a lesion of the pituitary gland can be controlled by radiotherapy, immediate surgical intervention is not indicated. I have in mind a case in which bilateral hemianopia was present. The patient was kept under observation for eighteen years, and he eventually died as a result of cardiac disease. He had been advised to undergo operation by a competent neurologist, but in my opinion an operation might have proved fatal because of his cardiac condition. The judicious administration of irradiation by Dr. Dyke from time to time kept the lesion from growing, and the patient's vision never was completely obliterated. He was a prominent attorney, and during the eighteen years in which he was under observation he maintained important responsibilities incident to his profession.

There are other conditions that simulate pituitary tumor, one of which is syphilis. The later manifestations of syphilis are not well known to many of the younger physicians. I have not seen syphilitic meningitis recently, but I used to encounter cases of it in which the disease was localized around the sella. The red, currant-jelly-like substance becomes fastened in the crevices of the skull, and the symptoms often simulate those of pontocerebellar tumor and also those of pituitary tumor. It is well to consider this entity, although syphilis is not so prevalent now as it was twenty years ago.

I am in accord with Dr. Davidoff's opinion concerning the surgical removal of chiasmal lesions and their susceptibility to irradiation. Aneurysm of the internal carotid artery sometimes is mistaken for a pituitary lesion, but the existence of an expanding lesion is easily detected. In cases of aneurysm one optic nerve is more involved than the other. Retrobulbar neuritis and obliteration of vision are manifest on one side long before the optic nerve on the opposite side is affected. At the same time, the olfactory bulb is involved, and too often when a patient with aneurysm comes to ophthalmic operation such factors as the olfactory function have not been examined. Perhaps this involvement should be recognized by the neurologist, who, after all, is the only remaining general practitioner. He does not overspecialize. In his examination he takes into consideration all the bodily functions and makes a complete physical examination.

I have noticed tendencies toward hypopituitarism in entire families. Each member is affected to a mild degree by acromegaly and manic-

depressive psychosis. In such cases the pituitary lesion is obscure. I should like to point out that it is impossible to define histologically where the pituitary gland terminates and the hypothalamus begins. Cells are present between the hypothalamus and the pituitary gland which have the characteristics of glandular cells and those of neural cells. Disease of the pituitary gland is often associated with symptoms referable to the hypothalamus. Thus, infantilism is often due to disturbances of a hypothalamic nature rather than to those of a pituitary nature. A young woman may acquire sudden acute insanity which has resulted from a manic-depressive psychosis. Her menses cease. The average physician might believe that if her menses can be restored, the patient will recover her mental status—in other words, that insanity has developed because menstruation has ceased. The truth is that menstruation has ceased for the same reason that the patient has lost the rhythm of her emotional life. The hypothalamus is the center of metabolic and emotional rhythm, and the pituitary gland is the center of endocrinologic function. As mentioned before, they merge, the one into the other.

COLLEGE OF PHYSICIANS OF PHILADELPHIA, SECTION ON OPHTHALMOLOGY

ALFRED COWAN, M.D., *Chairman*

WARREN S. REESE, M.D., *Secretary*

January 15, 1942

Some Clinical Aspects of the Blood Supply of the Optic Nerve and Chiasm. DR. DERRICK VAIL, Cincinnati (by invitation).

Since the finer details of the blood supply of the optic nerve and chiasm are not adequately described in the textbooks of ophthalmology, a review of the literature and a correlation of information from various sources should be of interest to ophthalmologists.

The anatomic variations of the portion of the chiasm and the blood vessels that make up the circle of Willis were discussed. The factors of clinical bearing were mentioned. Among these are the effects of pressure from the anomalous position of blood vessels, diseased atherotic vessels, inflammatory fibrous bands compressing the vessels and the optic nerve and the effect of tumors in the pituitary region. The central retinal artery itself apparently plays little part in nourishing the optic nerve.

Anatomic studies show that just before the central retinal artery pierces the arachnoid sheath of the optic nerve it sends a posterior collateral branch into the interior of the nerve, and it is this vessel that supplies the area of the papillomacular bundle. The periphery of the optic nerve is supplied by fine arterial twigs derived from the ophthalmic artery and its branches in the orbit. The pial network is the vessel-carrying structure in the nerve tissue. The intracanalicular portion is also supplied by the ophthalmic artery, but the pial network here is

exceedingly slight. The intracranial portion of the optic nerve is supplied by branches from the anterior portion of the circle of Willis, which penetrates the intracranial portion of the optic nerve from the outside inward.

Evidence was presented to indicate that the papillomacular bundle is particularly vulnerable in the intracranial portion of the nerve, and this may be the first site of lesions due to multiple sclerosis, syphilis and the inflammatory diseases.

The clinical conditions of subarachnoid hemorrhage, subdural hemorrhage, papilledema, embolism, edema of the septums, arachnoiditis, fracture, meningitis, tabes, aneurysm, sclerosis of the optic nerve vessels themselves and multiple sclerosis were discussed. In the recent work of F. B. Walsh and A. B. King (ARCH. OPHTH. **27**: 1 [Jan.] 1942) the extreme efficiency of the collateral circulation through the ophthalmic artery was emphasized. This aspect was discussed.

DETROIT OPHTHALMOLOGICAL SOCIETY

RALPH H. PINO, M.D., *President*

EDMOND L. COOPER, M.D., *Recorder*

February 26, 1942

Problems of Intraocular Surgery. DR. CONRAD BERENS, New York (by invitation).

Aspiration of fluid from the anterior chamber is often a helpful procedure in the treatment of glaucoma. It has an advantage over paracentesis in that the speed with which the fluid is withdrawn may be controlled. It may be performed as an office procedure. It is more effective in the treatment of secondary glaucoma than in the treatment of primary glaucoma and is also of value in the treatment of uveitis, corneal ulcer in which perforation of the cornea is imminent and embolism of the central retinal artery.

The Heine cyclodialysis is a procedure reserved by some ophthalmologists solely for use in cases of glaucoma secondary to cataract extraction. It is the operation of choice in those cases in which the intraocular pressure is moderately increased and fairly well controlled by means of the instillation of miotic agents.

Iridocorneosclerectomy combines the best features of the Lagrange sclerectomy, the Elliot corneoscleral trephining and the Holth iridencleisis. The technic may be combined with a transplantation from Tenon's capsule if the conjunctiva is thin or is accidentally buttonholed. Since the first report on this technic was published in 1936, 122 operations have been performed. Ninety per cent of 85 patients with chronic simple glaucoma had a postoperative intraocular pressure of 30 mm. of mercury (Schiøtz) or less.

A series of 1,004 cataract extractions performed at the New York Eye and Ear Infirmary was studied. In 302 the lens was removed intracapsularly; in the rest it was removed extracapsularly. Postoperative

complications of intracapsular and of extracapsular extractions were found to be about equal in seriousness and to occur with about the same frequency. Naturally, secondary membranes were more common after extracapsular extraction.

All but the finest capsular membranes should be cut with scissors because of the danger of traction on the ciliary processes with resulting iridocyclitis when the needle-knife is used. A sharp, hollow-ground, narrow keratome is used to penetrate the sclera subconjunctivally and to perforate the capsule. The incision in the capsule is then completed with iridocapsulotomy scissors (Berens' modification of Noyes's scissors), which fill the scleral opening and are easy to manipulate.

Exotropia caused by musculoscleral adhesions following operation for convergent strabismus may frequently be relieved by transplantation of a tongue of Tenon's capsule. I have performed this operation 13 times, and good results were obtained in 8 cases.

Correction of convergent strabismus, due to paralysis of the external rectus muscle, should be attempted by making use of one of the various transplantation operations. Perhaps the most suitable of these is transplantation of the lateral half of the superior and of the inferior rectus muscle to the attachment of the lateral rectus muscle. A transplantation of this type was performed on a patient with paralysis of the external rectus muscle, and the results were excellent. It was combined with a 6 mm. resection of the lateral rectus muscle and a 4 mm. recession of the medial rectus muscle. Binocular single vision was obtained, after which the patient was admitted to the Canadian and British air forces. Before operation he had an esotropia of 45 degrees for distance and of 40 degrees for near vision. After operation he had an esophoria of 10 degrees for distance and of 5 degrees for near vision. He could maintain binocular vision a little beyond the midline in the field of action of the paralyzed external rectus muscle.

Resection and transplantation of the superior oblique muscle after it is freed from the trochlea have given good results in cases of paralysis of the third cranial nerve (oculomotor).

RALPH H. PINO, M.D., *President*

EDMOND L. COOPER, M.D., *Recorder*

April 23, 1942

War Chemical Burns of the Eye. DR. JOHN G. BEALL, Ann Arbor, Mich. (by invitation).

Ophthalmologists are again confronted by the problems of the treatment of burns of the eye caused by war chemicals. The first problem concerns the malingerer who attempts to evade military service. Self mutilation is often difficult to distinguish, treat and cure.

The most serious chemical burns seen during combat are caused by the vesicant gases, for example mustard gas (dichlorodiethylsulfide), lewisite (dichlorobetachlorovinylarsine) and ethyldichloroarsine. In 75

per cent of all patients who suffer casualties caused by mustard gas, burns of the eyes are present. These are classified as mild, severe and corneal burns. Treatment includes (1) reassurance of the patient that he is not blind; (2) refraining from the use of bandages; (3) irrigation with a mild hypertonic, isotonic and neutralizing solution, such as chlorine water; (4) use of dark glasses, and (5) convalescent care.

For patients in whom the cornea is involved a few drops of a bland sterile oil should be instilled frequently during the first twenty-four hours. Patients with complications, especially secondary infection, should receive treatment consisting of local instillation of 5 to 10 per cent sulfathiazole (2-[paraaminobenzenesulfonamido]-thiazole) ointment and oral administration of 0.1 Gm. of sulfathiazole per kilogram of body weight every twenty-four hours.

Convalescence is best in a hospital where the services of a psychologist are available to treat the "shell shock" so often present. Patients with serious burns are often rendered inactive from duty for a period up to four months.

Ocular burns caused by the lacrimating gases, the lung irritants and the irritant smokes are treated symptomatically, as they do not cause damage to the eyes that fresh air and irrigations will not remedy unless the actual chemical is splashed into the eye. When the chemical is splashed in the eye, the burn is treated as an acid burn unless it was caused specifically by an alkali, such as ammonia. After the first World War there were only 14 cases of this type in which serious complications were reported. Ten of the patients had permanent visual impairment. Panophthalmitis occurred with loss of an eye in only 4 patients.

DISCUSSION

DR. HENRY DUNLAP: In a recent article in a leading medical journal the use of hydrogen peroxide in the treatment of war chemical burns was mentioned. Since Dr. Beall did not mention this treatment, I should like to ask him to comment on it now.

DR. JOHN G. BEALL: Hydrogen peroxide is a neutralizing agent and is used chiefly to irrigate the conjunctival sac.

Treatment of Amblyopia ex Anopsia. DR. HARVEY E. DOWLING.

Amblyopia ex anopsia may be defined as diminished visual acuity due to disuse of the eye. It is a condition which is much more apt to develop in a very young child than in an older one. After a child is 3 years old central fixation will not be lost within a year despite disuse, and after a child is 6 years old central fixation will not be lost at all.

Peters has described amblyopia ex anopsia as a condition in which the central visual acuity is lowered and a central scotoma is present. The scotoma is never absolute and is usually small (within 2 or 3 degrees of the fixation point). The peripheral fields in the amblyopic eye are smaller than in the fixing eye. Amblyopia is never present in association with alternating strabismus. The visual acuity in the amblyopic eye is usually less than 20/40 and better than 20/200. Treatment is best begun before the child is 6 years old.

The treatment of 34 patients with amblyopia ex anopsia consisted of forcing them to use the amblyopic eye. In 1 case this was accom-

plished by administering a cycloplegic agent to the fixing eye. In the other 33 cases the fixing eye was occluded by means of a shield. The average age at the beginning of treatment was 8.18 years, the youngest patient being 17 months old and the oldest patient 12 years. The length of treatment varied from one month to two years. Nine of the 34 patients had a visual acuity of 20/100 or better at the beginning of treatment.

The results of treatment were as follows: of the group, 32 per cent obtained a visual acuity of 20/20—5 or better; 64 per cent, a visual acuity of 20/30 or better; 76 per cent, a visual acuity of 20/40 or better, and 82 per cent, a visual acuity of 20/50 or better. In every patient in whom the visual acuity was 20/100 or better in the amblyopic eye when the treatment was begun, visual acuity of 20/40 or better was obtained. In 48 per cent of the patients in whom the visual acuity was less than 20/100 in the amblyopic eye when treatment was begun, visual acuity of 20/40 or better was obtained.

Occlusion of the amblyopic eye requires constant supervision by the parents of the patient and by the ophthalmologist. Occlusion must be constant to be effective; if it is less than constant it is of no value. The angle of deviation of the squinting eye will decrease as the amblyopia improves.

DISCUSSION

DR. C. S. BALLARD: I should like to ask Dr. Dowling what means he uses to occlude the fixing eye.

DR. HARVEY E. DOWLING: A simple and inexpensive occluder can be made from a piece of cardboard such as that used in making ordinary suit boxes. It is cut in the shape of a ping-pong paddle with a small hole in the handle end and a short slit at the opposite end. The temple piece of the patient's glasses is passed through the hole, and the nose piece is inserted into the slit. This effectively prevents use of the eye by all but the most persistent "peekers."

Recurrent Erosion of the Cornea. DR. J. C. GEMEROY.

A man was seen sixteen weeks after a dendritic ulceration appeared in the cornea of his right eye. The ulcer had reached the stage which Dr. Trygve Gunderson refers to as the "Lake Winnepesaukee stage." The ulcer was cauterized with tincture of iodine, the corneal epithelium being widely removed around the ulcerated area. When this procedure failed to effect a cure, the ulcer was cauterized with ether. Binocular occlusion of both eyes for seven days failed to produce any improvement. Oral administration of riboflavin (10 mg. daily) and thiamine hydrochloride (50 mg. daily) did not bring about noticeable improvement in the condition. A thorough examination for foci of infection was made, and all discovered foci were removed or treated.

The behavior of the ulcer during this period of treatment was most exasperating. The corneal epithelium would appear to heal almost completely and then in a day or two would break down, and a great deal of it would peel off. After this process had continued for some weeks in spite of treatment, a diagnosis of recurrent epithelial erosion of the cornea was made.

A suggestion by Dr. Sanford R. Gifford, Chicago, prompted the following steps: A small wedge of the inner margin of both the upper and the lower lid was removed with a von Graefe knife, a raw and bleeding surface being left. The epithelium over the entire cornea was removed with a dry cotton applicator. Absence of involvement of Bowman's membrane was noted at this time. A 15 per cent solution of trichloroacetic acid was then applied to the limbus throughout its extent, after which the eye was copiously irrigated. The lids were then sewn together with three black silk mattress sutures, the raw surfaces of the upper and of the lower lid margin being drawn together. The sutures were tied over small bits of rubber tubing to prevent their cutting through the skin. Forty-eight hours afterward all pain had disappeared and the patient was discharged from the hospital. The sutures were removed on the tenth day, by which time the lids had grown firmly together. At the end of three months the adhesions were severed and the lids were separated. The corneal epithelium was found to be perfectly normal. Corrected visual acuity was 20/30—2.

Tonometry. Dr. Erich Sachs.

Measurement of the intraocular pressure with the Schiøtz tonometer is subject to error because factors other than the intraocular pressure influence the reading. The three main sources of error in the use of this tonometer are poor construction of the instrument, faulty application of the instrument to the eye and incorrect interpretation of the data obtained. Poor construction of the instrument is responsible for false readings. Faulty application of the instrument to the eye provides inaccurate results. In spite of a perfectly constructed apparatus and correct application, the quantitative interpretation may be incorrect owing to the examiner's misconception of the basic principles involved. The imprintability of the cornea, although it is a manifestation of the intraocular pressure, by no means parallels it.

DISCUSSION

Dr. A. R. McKinney, Saginaw, Mich.: The incorrect application of the Schiøtz tonometer can frequently be eliminated as a source of error if the reading is taken by a second examiner while the first examiner keeps his attention firmly fixed on the point of application. Fixation of the patient's eye is also important. The patient should be given an object to look at which can easily be seen by him, and it should be placed in such a position that it will hold the eye in the primary position while the reading is being taken.

Myectomy of the Inferior Oblique Muscle. Dr. C. W. Lepard.

A colored motion picture was shown depicting the various steps necessary to the performance of myectomy of the inferior oblique muscle, approached through the lower lid according to the procedure recently described by James Watson White, of New York.

Book Reviews

Transactions of the American Ophthalmological Society. Seventy-Seventh Annual Meeting. Volume 39. Philadelphia: American Ophthalmological Society, 1941.

The program of the seventy-seventh annual meeting of the American Ophthalmological Society may be divided into clinical papers and those of a more scientific character. In the former class are reports by Knapp on "Operative Treatment of Subluxated Lens" and "Retinal Periphlebitis," Gradle and Sugar on "Wound Rupture after Cataract Extraction," Jackson on "Results of Cataract Extraction," Kirby on "Intracapsular Extraction," Beetham on a "Method of Cataract Extraction Employing Iridodialysis Instead of Iridectomy," Bedell on "Papilledema Without Increased Intracranial Pressure," Verhoeff on "Moore's Subjective Lightning Streaks," Benedict on "Blepharospasm," Dunphy and Albaugh on "Cyclodiathermy," Gifford on "Ring Ulcer," Cowan and Klauder on "Ocular Pemphigus," Lewis on "The Sulfonamides in Gonococcal Conjunctivitides" and O'Brien and Swan on "Doryl in Glaucoma Simplex." In the second class may be included the papers by Haden on "Development of the Vitreous," Samuels on "Lenticular Lesions Caused by Purulent Keratitis," Clapp on the "Capsular Epithelium in Immature Cataract," Reese and Calhoun on "Rhabdomyosarcoma of the Orbit," MacDonald on the "Ocular Kinetic Righting Reflex," Berens and associates on "Cultural Studies in Uveitis," Adler and MacDonald on the "Melanophore Hormone of the Pituitary in Retinitis Pigmentosa" and DeLong and Howland on "Findings with the Electron Microscope." Schoenberg's "Survey of the Records of Glaucoma Patients" is in the realm of preventive medicine and offers important suggestions. Many of these papers have been or will be published in the ARCHIVES or in the *American Journal of Ophthalmology* and need not be reviewed.

A special feature of the transactions is the publication in full of theses accepted from candidates for membership in the society. These are often too extensive for publication in the journals and are hence available only in the transactions. In recent years they have been of excellent quality, and some represent important contributions to the literature.

In the present volume Crawford reviews the subject of "Family Macular Degeneration" and reports on a new family with 8 members involved. Hill has studied "Changes in the Blindspot in Brain Trauma" and has reported his findings indicating that enlargement of the blindspot is a constant and early sign of diagnostic value. Horner has reviewed reported cases of "Dinitrophenol Cataract" with notes on his own observations of 19 eyes affected. Joy reports extensive experimental work on "Pyocyaneus Ulcer and Its Treatment with Sulfapyridine." James has reviewed the "Surgical Removal of Corneal Scars," described his use of air injected into the cornea to facilitate the procedure and reported his results in 10 cases. Pfeiffer contributes a review of "Roent-

genographic Findings in Orbital Conditions" with suggestions as to the various procedures necessary for complete evaluation of cases and the diagnostic accuracy achieved in a large series of cases. His report is illustrated freely and is of great value. The thesis of Wendell Hughes on "Reconstruction of the Eyelids" was too extensve for inclusion in the volume and is being published separately in the form of a monograph.

Great credit is due to the editor, Bernard Samuels, for his careful work in collecting and seeing through the press the material for this excellent volume.

SANFORD R. GIFFORD.

Complicacoes oftalmicas da sinusite maxilar (Ophthalmic Complications of Maxillary Sinusitis). By Octacilio Lopes, M.D. Pp. 278. São Paulo, Brazil: Empresa Gráfica da *Revista dos Tribunais,* 1942.

After an introduction on the anatomy of the maxillary sinus and of the orbit, in which the important relation of the orbit to the associated sinuses is stressed, the clinical symptoms of maxillary sinusitis are described, as well as the etiology, diagnosis and clinical course. The complications are then taken up, and those affecting the orbit are regarded as the most important. The complications consist in abscess of the orbit and palpebro-orbital abscess, thrombophlebitis and various inflammations of the interior of the eye, such as chorioretinitis, glaucoma, detachment of the retina and papillitis. A final chapter is devoted to the association of the maxillary sinuses with trachoma. The author was encouraged by the results obtained in the treatment of trachoma by treating the maxillary antrum, and a number of case reports are added.

ARNOLD KNAPP.

Nursing in Diseases of the Eye, Ear, Nose and Throat. By Members of the Staff of the Manhattan Eye, Ear, and Throat Hospital, New York. Seventh edition. Price, $2.50. Pp. 313, with 94 illustrations. Philadelphia: W. B. Saunders Company, 1942.

In the new edition of this book, which has previously been favorably commented on in these ARCHIVES (**18:** 686 [Oct.] 1937), the subject matter has been brought up to date. Certain chapters have been rewritten, and new sections have been added. The new subjects are foreign protein therapy; orthoptic training; treatment of syphilis of the eye, ear and throat; use of tuberculin in diagnosis and treatment; sulfanilamide and its derivatives, and allergy, vitamins and clinical pathology in ophthalmology and otorhinolaryngology. These additions are well written but are too condensed to serve as an adequate introduction, and it may be questioned whether they strictly belong to the problems of nursing.

ARNOLD KNAPP.

Directory of Ophthalmologic Societies *

INTERNATIONAL

International Association for Prevention of Blindness

President: Dr. P. Bailliart, 66 Boulevard Saint-Michel, Paris, 6e, France.
Secretary-General: Prof. M. Van Duyse, Université de Gand, Gand, Prov. Ostflandern, Belgium.
All correspondence should be addressed to the Secretariat, 66 Boulevard Saint-Michel, Paris, 6e, France.

International Ophthalmologic Congress

President: Prof. Nordenson, Serafimerlasarettet, Stockholm, Sweden.
Secretary: Dr. Ehlers, Jerbanenegade 41, Copenhagen, Denmark.

International Organization Against Trachoma

President: Dr. A. F. MacCallan, 17 Horseferry Rd., London, England.

Pan-American Congress of Ophthalmology

President: Dr. Harry S. Gradle, 58 E. Washington St., Chicago.
Executive Secretaries: Dr. Conrad Berens, 35 E. 70th St., New York. Dr. M. E. Alvaro, 1511 Consolacao, São Paulo, Brazil.

FOREIGN

All-India Ophthalmological Society

President: Dr. B. K. Narayan Rao, Minto Ophthalmic Hospital, Bangalore.
Secretary: Dr. G. Zachariah, Flitcham, Marshall's Rd., Madras.

British Medical Association, Section on Ophthalmology

President: Dr. W. Clark Souter, 9 Albyn Pl., Aberdeen, Scotland.
Secretary: Dr. Frederick Ridley, 12 Wimpole St., London, W. 1.

Chinese Ophthalmology Society

President: Dr. C. H. Chou. 363 Avenue Haig, Shanghai.
Secretary: Dr. F. S. Tsang, 221 Foochow Rd., Shanghai.

Chinese Ophthalmological Society of Peiping

President: Dr. H. T. Pi, Peiping Union Medical College, Peiping.
Secretary: Dr. C. K. Lin, 180 Hsi-Lo-yen Chienmeng, Peiping.
Place: Peiping Union Medical College, Peiping. Time: Last Friday of each month.

German Ophthalmological Society

President: Prof. W. Lohlein, Berlin.
Secretary: Prof. E. Engelking, Heidelberg.

Hungarian Ophthalmological Society

President: Prof. I. Iwre, Budapest.
Assistant Secretary: Dr. Stephen de Grósz, University Eye Hospital, Mária-utca 39, Budapest.
All corespondence should be addressed to the Assistant Secretary.

Midland Ophthalmological Society

President: Dr. W. Niccol, 4 College Green, Gloucester, England.
Secretary: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Place: Birmingham and Midland Eye Hospital.

*Secretaries of societies are requested to furnish the information necessary to make this list complete and keep it up to date.

NORTH OF ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. A. MacRae, 6 Jesmond Rd., Newcastle-upon-Tyne, England.
Secretary: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Place: Manchester, Bradford, Leeds, Newcastle-upon-Tyne, Liverpool and Sheffield, in rotation. Time: October to April.

OPHTHALMOLOGICAL SOCIETY OF AUSTRALIA

President: Dr. A. James Flynn, 135 Macquarie St., Sydney.
Secretary: Dr. D. Williams, 193 Macquarie St., Sydney

OPHTHALMOLOGICAL SOCIETY OF EGYPT

President: Prof. Dr. Mohammed Mahfouz Bey, Government Hospital, Alexandria.
Secretary: Dr. Mohammed Khalil, 4 Baehler St., Cairo.
All correspondence should be addressed to the secretary, Dr. Mohammed Khalil.

OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM

President: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Secretary: Mr. L. H. Savin, 7 Queen St., London, W. 1, England.

OPHTHALMOLOGY SOCIETY OF BOMBAY

President: Dr. D. D. Sathaye, 127 Girgaum Rd., Bombay 4, India.
Secretary: Dr. H. D. Dastur, Dadar, Bombay 14, India.
Place: H. B. A. Free Ophthalmic Hospital, Parel, Bombay 12. Time First Friday of every month.

OXFORD OPHTHALMOLOGICAL CONGRESS

Master: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Secretary-Treasurer: Dr. F. A. Anderson, 12 St. John's Hill, Shrewsbury, England.

PALESTINE OPHTHALMOLOGICAL SOCIETY

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Secretary: Dr. E. Sinai, Tel Aviv.

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Place: Lindley'a 4, Warsaw.

ROYAL SOCIETY OF MEDICINE, SECTION OF OPHTHALMOLOGY

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SÃO PAULO SOCIETY OF OPHTHALMOLOGY

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Secretary: Dr. Silvio de Almeido Toledo, Enfermaria Santa Luzia, Santa Casa de Misericordia, Cezario Motta St.—112, São Paulo, Brazil.

SOCIEDAD OFTALMOLOGIA DEL LITORAL, ROSARIO (ARGENTINA)

President: Prof. Dr. Carlos Weskamp, Laprida 1159, Rosario.
Secretary: Dr. Juan M. Vila Ortiz, Córdoba 1433, Rosario.
Place: Rosario. Time: Last Saturday of every month, April to November, inclusive.
All correspondence should be addressed to the President.

SOCIEDADE DE OPHTHALMOLOGIA E OTO RHINO-LARYNGOLOGIA DA BAHIA

President: Dr. Theonilo Amorim, Barra Avenida, Bahia, Brazil.
Secretary: Dr. Adroaldo de Alencar, Brazil.
All correspondence should be addressed to the President.

SOCIETÀ OFTALMOLOGICA ITALIANA

President: Prof. Dott. Giuseppe Ovio, Ophthalmological Clinic, University of Rome, Rome.
Secretary: Prof. Dott. Epimaco Leonardi, Via del Gianicolo, 1, Rome.

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Secretary: Dr. René Onfray, 6 Avenue de la Motte Picquet, Paris, 7e.

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President: Dr. D. Arieh-Friedman, 96 Allenby St., Tel Aviv, Palestine.
Secretary: Dr. Sadger Max, 9 Bialik St., Tel Aviv, Palestine.

NATIONAL

AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Conrad Berens, 35 E. 70th St., New York City.
Secretary: Dr. Derrick Vail, 441 Vine St., Cincinnati.
Place: San Francisco.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, SECTION ON OPHTHALMOLOGY

President: Dr. Ralph I. Lloyd, 14–8th Ave., Brooklyn.
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President: Dr. J. Vaillancourt, 46 St. Louis St., Quebec.
Secretary-Treasurer: Dr. Alexander E. MacDonald, 421 Medical Arts Bldg., Toronto.

NATIONAL SOCIETY FOR THE PREVENTION OF BLINDNESS

President: Mr. Mason H. Bigelow, 1790 Broadway, New York.
Secretary: Miss Regina E. Schneider, 1790 Broadway, New York.
Executive Director: Mrs. Eleanor Brown Merrill, 1790 Broadway, New York.

SECTIONAL

ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. Charles W. Barkhorn, 223 Roseville Ave., Newark.
Secretary: Dr. William F. McKim, 317 Roseville Ave., Newark.
Place: 91 Lincoln Park South, Newark. Time: 8:45 p. m., second Monday of each month, October to May.

CENTRAL WISCONSIN SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. D. G. Hugo, 130 Main St., Oshkosh.
Secretary: Dr. G. L. McCormick, 626 S. Central Ave., Marshfield.
Time: October 1942.

NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. William D. Rowland, 84 Commonwealth Ave., Boston.
Secretary-Treasurer: Dr. Trygve Gundersen, 243 Charles St., Boston.
Place: Massachusetts Eye and Ear Infirmary, 243 Charles St., Boston, Time: 8 p. m. third Tuesday of each month from November to April, inclusive.

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

President: Dr. Ralph A. Fenton, 1020 S. W. Taylor St., Portland, Ore.
Secretary-Treasurer: Dr. C. Allen Dickey, 450 Sutter St., San Francisco.

PUGET SOUND ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Spencer S. Howe, 103 E. Holly St., Bellingham, Wash.
Secretary-Treasurer: Dr. Barton E. Peden, 419 Stimson Bldg., Seattle.
Place: Seattle or Tacoma, Wash. Time: Third Tuesday of each month except June, July and August.

ROCK RIVER VALLEY EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. J. Sheldon Clark, 27 E. Stephenson St., Freeport, Ill.
Secretary-Treasurer: Dr. Harry R. Warner, 321 W. State St., Rockford, Ill.
Place: Rockford, Ill., or Janesville or Beloit, Wis. Time: Third Tuesday of each month from October to April, inclusive.

SAGINAW VALLEY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. M. Kessler, 311 Center Ave., Bay City, Mich.
Secretary-Treasurer: Dr. J. H. Curts, 330 S. Washington Ave., Saginaw, Mich.
Place: Saginaw or Bay City, Mich. Time: Second Tuesday of each month, except July and August.

SIOUX VALLEY EYE AND EAR ACADEMY

President: Dr. J. C. Davis, 1615 Howard St., Omaha.
Secretary-Treasurer: Dr. J. E. Dvorak, 408 Davidson Bldg., Sioux Falls, S. D.

SOUTHERN MEDICAL ASSOCIATION, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. L. Chester McHenry, Medical Arts Bldg., Oklahoma City.
Secretary: Dr. J. W. Jervey Jr., 101 Church St., Greenville, S. C.
Place: Richmond, Va. Time: November 1942.

SOUTHWESTERN ACADEMY OF EYE, EAR, NOSE AND THROAT

President: Dr. H. L. Brehmer, 221 W. Central Ave., Albuquerque, N. Mex.
Secretary: Dr. A. E. Cruthirds, 1011 Professional Bldg., Phoenix, Ariz.
Place: Albuquerque, N. Mex. Time: November 1942.

SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President: Dr. W. M. Dodge, 716 First National Bank Bldg., Battle Creek.
Secretary-Treasurer: Dr. Kenneth Lowe, 25 W. Michigan Ave., Battle Creek.
Time: Last Thursday of September, October, November, March, April and May.

WESTERN PENNSYLVANIA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. C. H. Bailey, 29 S. Oakland Ave., Sharon.
Secretary-Treasurer: Dr. J. McClure Tyson, Deposit Nat'l Bank Bldg., DuBois.

STATE

ARKANSAS STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. R. R. Kirkpatrick, 6th and Walnut Sts., Texarkana, Ark.
Secretary-Treasurer: Dr. Raymond C. Cook, 701 Main St., Little Rock.

COLORADO OPHTHALMOLOGICAL SOCIETY

President: Dr. William M. Bane, 1612 Tremont Pl., Denver.
Secretary: Dr. Harry Shankel, Republic Bldg., Denver.
Place: University Club, Denver. Time: 7:30 p. m., third Saturday of each month, October to May, inclusive.

Connecticut State Medical Society, Section on Eye, Ear, Nose and Throat

President: Dr. Edward N. DeWitt, 836 Myrtle Ave., Bridgeport.
Secretary-Treasurer: Dr. Henry L. Birge, 179 Allyn St., Hartford.

Eye, Ear, Nose and Throat Club of Georgia

President: Dr. E. N. Maner, 247 Bull St., Savannah.
Secretary-Treasurer: Dr. C. K. McLaughlin, 567 Walnut St., Macon.

Indiana Academy of Ophthalmology and Oto-Laryngology

President: Dr. F. McK. Ruby, Union City.
Secretary: Dr. Edwin W. Dyar Jr., 23 E. Ohio St., Indianapolis.
Place: French Lick. Time: First Wednesday in April.

Iowa Academy of Ophthalmology and Oto-Laryngology

President: Dr. J. K. Von Lackum, 117-3d St. S. E., Cedar Rapids.
Secretary-Treasurer: Dr. B. M. Merkel, 604 Locust St., Des Moines.

Lousiana-Mississippi Ophthalmological and Otolaryngological Society

President: Dr. Henry N. Blum, 912 American Bank Bldg., New Orleans.
Secretary-Treasurer: Dr. Edley H. Jones, 1301 Washington St., Vicksburg, Miss.

Michigan State Medical Society, Section of Ophthalmology and Otolaryngology

Chairman: Dr. Robert H. Fraser, 25 W. Michigan Ave., Battle Creek.
Secretary: Dr. R. G. Laird, 114 Fulton St., Grand Rapids.

Minnesota Academy of Ophthalmology and Otolaryngology

President: Dr. Erling Wilhelm Hansen, 78 S. 9th St., Minneapolis.
Secretary-Treasurer: Dr. George E. McGeary, 920 Medical Arts Bldg., Minneapolis.
Time: Second Friday of each month from October to May.

Montana Academy of Oto-Ophthalmology

President: Dr. William J. Marshall, 335 Owen St., Missoula.
Secretary: Dr. Fritz D. Hurd, 309 Medical Arts Bldg., Great Falls.

Nebraska Academy of Ophthalmology and Otolaryngology

President: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. John Peterson, 1307 N St., Lincoln.

New Jersey State Medical Society, Section on Ophthalmology, Otology and Rhinolaryngology

Chairman: Dr. Edgar P. Cardwell, 47 Central Ave., Newark.
Secretary: Dr. Arthur E. Sherman, 243 S. Harrison St., East Orange.

New York State Medical Society, Eye, Ear, Nose and Throat Section

Chairman: Dr. Searle B. Marlow, 109 S. Warren St., Syracuse.
Secretary: Dr. C. Stewart Nash, 277 Alexander St., Rochester.

North Carolina Eye, Ear, Nose and Throat Society

President: Dr. M. R. Gibson, Professional Bldg., Raleigh.
Secretary: Dr. Vanderbilt F. Couch, 105 W. 4th St., Winston-Salem.

North Dakota Academy of Ophthalmology and Oto-Laryngology

President: Dr. G. A. Larson, 114 Roberts St., Fargo.
Secretary-Treasurer: Dr. F. L. Wicks, 516–6th St., Valley City.

OREGON ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Paul Bailey, 833 S. W. 11th Ave., Portland.
Secretary-Treasurer: Dr. R. S. Fixott, 1020 S. W. Taylor St., Portland.
Place: Good Samaritan Hospital, Portland. Time: Third Tuesday of each month.

RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

Acting President: Dr. N. Darrell Harvey, 112 Waterman St., Providence.
Secretary-Treasurer: Dr. Linley C. Happ, 124 Waterman St., Providence.
Place: Rhode Island Medical Society Library, Providence. Time: 8:30 p. m., second Thursday in October, December, February and April.

SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. J. L. Sanders, 222 N. Main St., Greenville.
Secretary: Dr. J. H. Stokes, 125 W. Cheves St., Florence.
Place: Columbia. Time: November 1942.

TENNESSEE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Wesley Wilkerson, 700 Church St., Nashville.
Secretary-Treasurer: Dr. W. D. Stinson, 124 Physicians and Surgeons Bldg., Memphis.

TEXAS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. E. L. Goar, 1300 Walker Ave., Houston.
Secretary: Dr. Dan Brannin, 929 Medical Arts Bldg., Dallas.

UTAH OPHTHALMOLOGICAL SOCIETY

President: Dr. Everett B. Muir, Boston Bldg., Salt Lake City.
Secretary-Treasurer: Dr. Earl H. Phillips, 623 Judge Bldg., Salt Lake City.
Place: University Club, Salt Lake City. Time: 7:00 p. m., third Monday of each month.

VIRGINIA SOCIETY OF OTO-LARYNGOLOGY AND OPHTHALMOLOGY

President: Dr. Mortimer H. Williams, 30½ Franklin Rd. S. W., Roanoke.
Secretary-Treasurer: Dr. Meade Edmunds, 34 Franklin St., Petersburg.

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. George Traugh, 309 Cleveland Ave., Fairmont.
Secretary: Dr. Welch England, 621½ Market St., Parkersburg.

LOCAL

AKRON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. George E. Ferguson, Second National Bldg., Akron, Ohio.
Secretary-Treasurer: Dr. D. F. Mathias, First Central Tower, Akron, Ohio.
Time: First Monday in January, March, May and November.

ATLANTA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Stacy C. Howell, 144 Ponce de Leon Ave. N. E., Atlanta, Ga.
Secretary: Dr. Lester A. Brown, 478 Peachtree St. N. E., Atlanta, Ga.
Place: Grady Hospital. Time: 6:00 p. m., second Wednesday of each month, from October to May.

BALTIMORE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Ernst Bodenheimer, 1212 Eutaw Pl., Baltimore.
Secretary: Dr. Thomas R. O'Rourk, 104 W. Madison St., Baltimore.
Place: Medical and Chirurgical Faculty, 1211 Cathedral St. Time: 8:30 p. m., fourth Thursday of each month from October to March.

Birmingham Eye, Ear, Nose and Throat Club

President: Each member, in alphabetical order.
Secretary: Dr. Luther E. Wilson, 919 Woodward Bldg., Birmingham, Ala.
Place: Tutwiler Hotel. Time: 6:30 p. m., second Tuesday of each month, September to May, inclusive.

Brooklyn Ophthalmological Society

President: Dr. William B. Agan, 1 Nevins St., Brooklyn.
Secretary-Treasurer: Dr. Benjamin C. Rosenthal, 140 New York Ave., Brooklyn.
Place: Kings County Medical Society Bldg., 1313 Bedford Ave. Time: Third Thursday in February, April, May, October and December.

Buffalo Ophthalmologic Club

President: Dr. Meyer H. Riwchun, 367 Linwood Ave., Buffalo.
Secretary-Treasurer: Dr. Sheldon B. Freeman, 196 Linwood Ave., Buffalo.
Time: Second Thursday of each month.

Chattanooga Society of Ophthalmology and Otolaryngology

President: Each member, in alphabetical order.
Secretary: Dr. Douglas Chamberlain, Chattanooga Bank Bldg., Chattanooga, Tenn.
Place: Mountain City Club. Time: Second Thursday of each month from September to May.

Chicago Ophthalmological Society

President: Dr. Sanford Gifford, 720 N. Michigan Ave., Chicago.
Secretary-Treasurer: Dr. Vernon M. Leech, 55 E. Washington St., Chicago.
Place: Chicago Towers Club, 505 N. Michigan Ave. Time: Third Monday of each month from October to May.

Cincinnati General Hospital Ophthalmology Staff

Chairman: Dr. D. T. Vail, 441 Vine St., Cincinnati.
Secretary: Dr. A. A. Levin, 441 Vine St., Cincinnati.
Place: Cincinnati General Hospital. Time: 7:45 p. m., third Friday of each month except June, July and August.

Cleveland Ophthalmological Club

Chairman: Dr. W. J. Abbott, 10515 Carnegie Ave., Cleveland.
Secretary: Dr. L. V. Johnson, 2065 Adelbert Rd., Cleveland.
Time: Second Tuesday in October, December, February and April.

College of Physicians, Philadelphia, Section on Ophthalmology

Chairman: Dr. Francis H. Adler, 313 S. 17th St., Philadelphia.
Clerk: Dr. W. S. Reese, 1901 Walnut St., Philadelphia.
Time: Third Thursday of every month from October to April, inclusive.

Columbus Ophthalmological and Oto-Laryngological Society

Chairman: Dr. C. D. Postle, 240 E. State St., Columbus, Ohio.
Secretary-Treasurer: Dr. Hugh C. Thompson, 289 E. State St., Columbus, Ohio.
Place: The Neil House. Time: 6 p. m., first Monday of each month.

Corpus Christi Eye, Ear, Nose and Throat Society

Chairman: Dr. F. K. Stroud, 416 Chaparral St., Corpus Christi, Texas.
Secretary: Dr. Arthur Padilla, 414 Medical Professional Bldg., Corpus christi, Texas.
Time: Second Friday of each month from October to May.

Dallas Academy of Ophthalmology and Oto-Laryngology

President: Dr. S. F. Harrington, 921 Medical Arts Bldg., Dallas, Texas.
Secretary: Dr. Abell Hardin, Medical Arts Bldg., Dallas, Texas.
Place: Dallas Athletic Club. Time: 6:30 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Des Moines Academy of Ophthalmology and Otolaryngology

President: Dr. H. C. Schmitz, 604 Locust St., Des Moines, Iowa.
Secretary-Treasurer: Dr. Byron M. Merkel, 604 Locust St., Des Moines, Iowa.
Time: 7:45 p. m., third Monday of every month from September to May.

Detroit Ophthalmological Club

Chairman: Members rotate alphabetically.
Secretary: Dr. Harvey E. Dowling, 2414 Eaton Tower, Detroit.
Time: 6:30 p. m., first Wednesday of each month.

Detroit Ophthalmological Society

President: Dr. Parker Heath, 1553 Woodward Ave., Detroit.
Secretary: Dr. Leland F. Carter, 1553 Woodward Ave., Detroit.
Place: Club rooms of Wayne County Medical Society. Time: Third Thursday of each month from November to April, inclusive.

Eastern New York Eye, Ear, Nose and Throat Association

President: Dr. James M. Dunn, 1352 Union St., Schenectady.
Secretary-Treasurer: Dr. Joseph L. Holohan, 330 State St., Albany.
Time: Third Wednesday in October, November, March, April, May and June.

Eastern Pennsylvania Association of Eye, Ear, Nose and Throat Physicians

President: Dr. James E. Landis, 232 N. 6th St., Reading.
Secretary-Treasurer: Dr. Sterling F. Mengel, 612 W. Market St., Pottsville.
Time: Last week in April each year.

Fort Worth Eye, Ear, Nose and Throat Society

President: Dr. W. R. Thompson, 602 W. 10th St., Fort Worth, Texas.
Secretary-Treasurer: Dr. A. E. Jackson, 602 W. 10th St., Fort Worth, Texas.
Place: Medical Hall, Medical Arts Bldg. Time: 7:30 p. m., first Friday of each month except July and August.

Houston Academy of Medicine, Ophthalmological and Oto-Laryngological Section

President: Dr. Felician J. Slataper, 1110-1111 Medical Arts Bldg., Houston, Texas.
Secretary: Dr. Theo. L. Holland, 611 Medical Arts Bldg., Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., second Thursday of each month from September to June.

Indianapolis Ophthalmological and Otolaryngological Society

President: Dr. John I. Garret, 57 Stokes Bldg., Indianapolis.
Secretary: Dr. Kenneth L. Craft, 23 E. Ohio St., Indianapolis.
Place: Indianapolis Athletic Club. Time: 6:30 p. m., second Thursday of each month from November to May.

Kansas City Society of Ophthalmology and Oto-Laryngology

President: Dr. Homer Beal, 1103 Grand Ave., Kansas City, Mo.
Secretary: Dr. Desmond Curran, Federal Reserve Bank Bldg., Kansas City, Mo.
Time: Third Thursday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Long Beach Eye, Ear, Nose and Throat Society

Chairman: Dr. Harold Snow, 614 S. Pacific Ave., San Pedro, Calif.
Secretary-Treasurer: Dr. Oliver R. Nees, 508 Times Bldg., Long Beach, Calif.
Place: Professional Bldg. Time: Last Wednesday of each month from October to May.

Los Angeles Society of Ophthalmology and Otolaryngology

President: Dr. John Osburn, 523 W. 6th St., Los Angeles.
Secretary-Treasurer: Dr. Colby Hall, 1136 W. 6th St., Los Angeles.
Place: Los Angeles County Medical Association Bldg., 1925 Wilshire Blvd. Time: 6:00 p. m., fourth Monday of each month from September to May, inclusive.

Louisville Eye and Ear Society

President: Dr. Joseph S. Heitger, Heyburn Bldg., Louisville, Ky.
Secretary-Treasurer: Dr. J. W. Fish, 321 W. Broadway, Louisville, Ky.
Place: Brown Hotel. Time: 6:30 p. m., second Thursday of each month from September to May, inclusive.

Lower Anthracite Eye, Ear, Nose and Throat Society

Chairman: Each member in alphabetical order.
Secretary: Dr. James J. Monohan, 31 S. Jardin St., Shenandoah, Pa.

Medical Society of the District of Columbia, Section of Ophthalmology and Otolaryngology

Chairman: Dr. E. J. Cummings, 1835 I St. N. W., Washington.
Secretary: Dr. P. S. Constantinople, 1835 I St. N. W., Washington.
Place: 1718 M St. N. W. Time: 8 p. m., third Friday of each month from October to April, inclusive.

Memphis Society of Ophthalmology and Otolaryngology

Chairman: Each member in alphabetical order.
Secretary: Dr. Sam H. Sanders, 1089 Madison Ave., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month from September to May.

Milwaukee Oto-Ophthalmic Society

President: Dr. John W. Truitt, 161 W. Wisconsin Ave., Milwaukee.
Secretary-Treasurer: Dr. Ralph T. Rank, 238 W. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., second Tuesday of each month.

Montgomery County Medical Society

Chairman: Dr. H. V. Dutrow, 1040 Fidelity Medical Bldg., Dayton, Ohio.
Secretary-Treasurer: Dr. Maitland D. Place, 981 Reibold Bldg., Dayton, Ohio.
Place: Van Cleve Hotel. Time: 6:30 p. m., first Tuesday of each month from October to June, inclusive.

Montreal Ophthalmological Society

President: Dr. J. Rosenbaum, 1396 Ste. Catherine St. W., Montreal, Canada.
Secretary: Dr. L. Tessier, 1230 St. Joseph Blvd. E., Montreal, Canada.
Time: Second Thursday of October, December, February and April.

Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. Andrew Hollabaugh, Doctors Bldg., Nashville, Tenn.
Secretary: Dr. Guy Maness, Medical Arts Bldg., Nashville, Tenn.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month from October to May.

New Haven Ophthalmological Society

President: Dr. William H. Ryder, 185 Church St., New Haven, Conn.
Secretary: Dr. Frederick A. Wiess, 255 Bradley St., New Haven, Conn.

New Orleans Ophthalmological and Otolaryngological Society

President: Dr. W. B. Clark, 1012 American Bank Bldg., New Orleans.
Secretary: Dr. Mercer G. Lynch, 1018 Maison Blanche Bldg., New Orleans.
Place: Louisiana State University Medical Bldg. Time: 8 p. m., second Tuesday of each month from October to May.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Chairman: Dr. Kaufman Schlivek, 1016–5th Ave., New York.
Secretary: Dr. Brittain Payne, 896 Madison Ave., New York.
Time: 8:30 p. m., third Monday of every month from October to May, inclusive.

NEW YORK SOCIETY FOR CLINICAL OPHTHALMOLOGY

President: Dr. Isidore Givner, 108 E. 66th St., New York.
Secretary: Dr. Benjamin Esterman, 983 Park Ave., New York.
Place: Squibb Hall, 745–5th Ave. Time: 8 p. m., first Monday of each month from October to May, inclusive.

OKLAHOMA CITY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. R. E. Leatherock, Cushing, Okla.
Secretary: Dr. Harry C. Ford, 1014 Medical Arts Bldg., Oklahoma City.
Place: University Hospital. Time: Second Tuesday of each month from September to May.

OMAHA AND COUNCIL BLUFFS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. Leo P. Coakley, 918 Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Place: Omaha Club, 20th and Douglas Sts., Omaha. Time: 6 p. m. dinner; 7 p. m., program; third Wednesday of each month from October to May.

PASSAIC-BERGEN OPHTHALMOLOGICAL CLUB

President: Dr. L. Markowitz, 16 Church St., Paterson, N. J.
Secretary-Treasurer: Dr. A. John Reinhorn, 302 Broadway, Paterson, N. J.
Place: Paterson Eye and Ear Infirmary. Time: 9 p. m., last Friday of every month, except June, July and August.

PHILADELPHIA COUNTY MEDICAL SOCIETY, EYE SECTION

Chairman: Dr. Edmund B. Spaeth, 1930 Chestnut St., Philadelphia.
Secretary: Dr. Wilfred E. Fry, 1819 Chestnut St., Philadelphia.
Time: First Thursday of each month from October to May.

PITTSBURGH OPHTHALMOLGICAL SOCIETY

President: Dr. J. Clyde Markel, 200–9th St., Pittsburgh.
Secretary: Dr. George H. Shuman, 351–5th Ave., Pittsburgh.
Place: Pittsburgh Academy of Medicine Bldg. Time: Fourth Monday of each month, except June, July, August and September.

READING EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Solon L. Rhode, 238 N. 6th St., Reading, Pa.
Secretary: Dr. Paul C. Craig, 232 N. 5th St., Reading, Pa.
Place: Wyomissing Club. Time: 6:30 p. m., third Wednesday of each month from October to July.

RICHMOND OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. W. F. Bryce, Medical Arts Bldg., Richmond, Va.
Secretary: Dr. Richard W. Vaughan, Medical Arts Bldg., Richmond, Va.
Place: Westmoreland Club. Time: 6 p. m., second Monday of each month from October to May.

ROCHESTER EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. E. J. Avery, 11 N. Goodman St., Rochester N. Y.
Secretary-Treasurer: Dr. Charles T. Sullivan, 277 Alexander St., Rochester, N. Y.

St. Louis Ophthalmic Society

President: Dr. William M. James, 508 N. Grand Blvd., St. Louis.
Secretary: Dr. H. Rommel Hildreth, 823 Metropolitan Bldg., St. Louis.
Place: Oscar Johnson Institute. Time: Clinical meeting, 5:30 p. m., dinner and scientific meeting 6:30 p. m., fourth Friday of each month from October to April, inclusive, except December.

San Antonio Ophthalmo-Oto-Laryngological Society

President: Dr. Dan Russell, 705 E. Houston St., San Antonio, Texas.
Secretary-Treasurer: Dr. P. G. Bowen, 315 Camden St., San Antonio, Texas,
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

San Francisco County Medical Society, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Fred Boyle, 490 Post St., San Francisco.
Secretary: Dr. Frank Hand, 450 Sutter St., San Francisco.
Place: Society's Bldg., 2180 Washington St., San Francisco. Time: Fourth Tuesday of every month except June, July and December.

Shreveport Eye, Ear, Nose and Throat Society

President: Dr. David C. Swearingen, Slattery Bldg., Shreveport, La.
Secretary-Treasurer: Dr. Kenneth Jones, Medical Arts Bldg., Shreveport, La.
Place: Shreveport Charity Hospital. Time: 7:30 p. m., first Monday of every month except July, August and September.

Spokane Academy of Ophthalmology and Oto-Laryngology

President: Dr. Louis A. Parsell, 407 Riverside Ave., Spokane, Wash.
Secretary: Dr. Robert L. Pohl, 407 Riverside Ave., Spokane, Wash.
Place: Paulsen Medical and Dental Library. Time: 8 p. m., fourth Tuesday of each month except June, July and August.

Syracuse Eye, Ear, Nose and Throat Society

President: Dr. Roy Seeley Moore, 1704 State Tower Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. I. H. Blaisdell, 713 E. Genesee St., Syracuse, N. Y.
Place: University Club. Time: First Tuesday of each month except June, July and August.

Toledo Eye, Ear, Nose and Throat Society

Chairman: Dr. John D. Skow, 2001 Collingwood Blvd., Toledo, Ohio.
Secretary: Dr. S. H. Patterson, 125–15th Ave., Toledo, Ohio.
Place: Toledo Club. Time: Each month except June, July and August.

Toronto Academy of Medicine, Section of Ophthalmology

Chairman: Dr. W. R. F. Luke, 316 Medical Arts Bldg., Toronto, Canada.
Secretary: Dr. W. T. Gratton, 216 Medical Arts Bldg., Toronto, Canada.
Place: Academy of Medicine, 13 Queens Park. Time: First Monday of each month, November to April.

Washington, D. C., Ophthalmological Society

President: Dr. E. Leonard Goodman, 1801 I St. N. W., Washington, D. C.
Secretary-Treasurer: Dr. Sterling Bockoven, 1752 Massachusetts Ave. N. W., Washington, D. C.
Place: Episcopal Eye, Ear and Throat Hospital. Time: 7:30 p. m., first Monday in November, January, March and April.

Wilkes-Barre Ophthalmological Society

Chairman: Each member in turn.
Secretary: Dr. Samuel T. Buckman, 70 S. Franklin St., Wilkes-Barre, Pa.
Place: Office of chairman. Time: Last Tuesday of each month from October to May.